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BULLETIN OF THE TORREY BOTANICAL CLUB
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FLORAL ELEMENTS OF THE PINE-OAK-LIQUIDAMBAR FOREST OF MONTEBELLO, CHIAPAS, MEXICO[1]

MARGERY C. CARLSON

The flora of certain forests of the high plateaus of Mexico and Central America is particularly interesting because it contains elements which are predominately northern as well as elements which are tropical. Fernald (1931) reported that certain plants of the tablelands of the Appalachian mountains, of the Atlantic Coastal Plain, and of the Ozark Plateau are found also in certain high-plateau forests of Mexico and Central America.

Miranda and Sharp (1950) made a comparative study of some of the high forests located at intervals along the eastern escarpment of the Central Mesa of Mexico, from Xilitla, S. L. P., to Orizaba, Ver., and in certain highlands of Oaxaca and Chiapas. They describe 9 forest types, of which the mixed-oak, pure-oak, *Liquidambar*, pine, and sycamore forests are the most extensive and widely distributed. Some species in these forests are common to temperate Mexico and southeastern United States, the areas in Mexico occupied by these species appearing "to be indicated in a general way by the known distribution of *Liquidambar*."

Steyermark (1950) pointed out the remarkable relationship between the vegetation of the "old mountains" of Guatemala and that of certain parts of the United States. He says, "These mountains, formed of Paleozoic and Mesozoic rocks, are part of an ancient nuclear core of Central America, and have been available for plant occupation since the end of the Cretaceous period. Many genera whose ancestry dates back to late Cretaceous and early Tertiary times occur only in this area of ancient strata." The relationship with the flora of the United States "is two-fold, (1) consisting of species related to the flora of eastern United States, and (2) of those related to the flora of the Rocky Mountains or southwestern United States."

The forest visited in connection with this study is located about 35 miles southeast of Comitán, Chiapas, on the border between Mexico and Guatemala (fig. 1). The area on the Mexican side of the border covers roughly 50 square miles. It has an irregular outline and is cut almost into two parts by the valley of one of the tributaries of the Jatate River. Only the southwest half was visited.

The terrain is rough, with hills of varying size and height, lakes, and depressions, some of which contain water during the wet season. A chain of lakes, the largest called Tepancuapan, lies in the valley of a river, the

[1] Tables published with the aid of the Lucien M. Underwood Memorial Fund.

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Río Grande de Comitán. One of the tributaries, a spring-fed stream, also widens in several places to form lakes. Being sluggish in its high valley, the river suddenly plunges down a narrow canyon, flows under a natural bridge and disappears into a large cave. Other lakes, scattered through the forest, have no visible inlets or outlets. The largest of these is Montebello, from which the whole area takes its name. The lakes are noted for their unusual colors, from almost black to a pale green. Some of them are bordered by steep slopes or white limestone cliffs, others have more gently sloping borders and beaches (fig. 2).

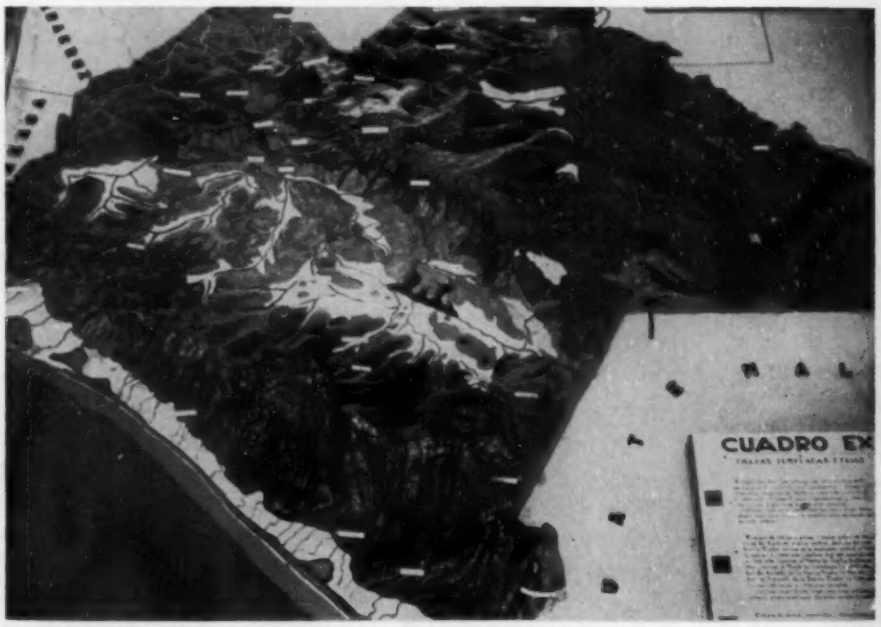

FIG. 1. Relief map of the state of Chiapas, Mexico, showing vegetation regions. Map, prepared by Dr. F. Miranda, is in the Instituto Botánico in Tuxtla Gutierrez, Chiapas. Montebello is indicated by the arrow; Comitán by the "X." Other *Liquidambar* forests in same shade as that of Montebello.

The altitude of the areas varies from 1,400 to 1,700 meters. The temperatures range from 12° to 22° C., April and May being the warmest months, December and January, the coldest. The average annual rainfall varies from 125 to 170 cm. (data furnished by Dr. Faustino Miranda, Director, Botanical Institute, Tuxtla Gutierrez, Chiapas). Rains may occur all through the year, but the heaviest are in September and October and the lightest from March to May. Even in the driest months fogs and drizzles occur, especially at night.

This investigation was partially supported by grants from the American

Philosophical Society of Philadelphia, Pa., and the Garden Club of Evanston, Illinois. The plants were identified by Drs. Paul C. Standley, L. Williams, Julian Steyermark, C. V. Morton, and L. B. Smith, to whom grateful appreciation is extended. The plants are deposited in the herbaria of the Chicago Natural History Museum, the Escuela Agrícola Panamericana, Tegucigalpa, Honduras, and the Instituto de Biología in Mexico City.

Methods. Visits to the forest were made in April, 1949 and in January, 1952. Camps were established on the shores of some of the lakes and trips were made from these in all directions, either on the trails which criss-

FIG. 2. One of the smaller lakes at Montebello, surrounded by steep slopes. Forest of pines, oaks, and *Liquidambar*.

cross the forest, or directly into it. About 300 species, representing 171 genera and 85 families, were collected. Although not complete, this collection of plants is probably representative of the whole flora of the forest. Notes were made of the habitat, the habit of growth and the relative abundance of each species. After the identifications were completed, the distribution, particularly in the western hemisphere, of each genus and species was recorded from several appropriate floras and manuals.

Results. The data are presented in the accompanying list which includes all species, with their collection numbers, arranged in alphabetical order by family. They are grouped as (1) trees of the overstory, (2) undergrowth of smaller trees and shrubs, (3) herbs and vines of the forest floor,

(4) plants of the lake shores and beaches, (5) pteridophytes, and (6) epiphytes. Those marked with one asterisk (*) are species native also to the United States; those with two (**), species of genera found in the United States; with (†), those which are endemic to Mexico and Central America; and those with (††), species which are of wide tropical distribution.

1. TREES OF THE OVERSTORY:

Fagaceae
- **† *Quercus candicans* Née (*Q. calophylla* Cham. & Schlecht.), 1841, 2349
- **† *Q. crispipilis* Trel., 2313
- **† *Q. peduncularis* Née, 2315
- **† *Q. polymorpha* Schl. & Cham., 1922
- **† *Q. sapotaefolia* Liebm., 1840, 1844
- **† *Q. segoviensis* Liebm., 2316
- ** *Q.* sp., 2349

Hamamelidaceae
- * † *Liquidambar Styraciflua* L., 1729

Pinaceae
- **† *Pinus Montezumae* Martínez, 1911
- **† *P. oocarpa* Schiede, 1843, 2348

2. UNDERGROWTH OF SMALLER TREES AND SHRUBS:

Anacardiaceae
- **† *Rhus terebinthifolia* Schlecht. & Cham., 1832

Araliaceae
- † *Oreopanax xalapensis* (HBK.) Dene. & Planch., 2225
- † *O. peltatus* Linden, 2268
- † *O. Sanderianus* Hemsl., 2351

Bignoniaceae
- †† *Godmania aesculifolia* (HBK.) Standl., 1828

Caprifoliaceae
- **† *Viburnum guatemalense* Gandog., 1704

Celastraceae
- † *Wimmeria concolor* Schlecht. & Cham., 2247
- † *Zinowiewia densiflora* Standl. & L. Wms., ex desc., 2350

Clethraceae
- **† *Clethra Carlsoniae* Standl. & L. Wms., ex desc., 2231

Compositae
- **† *Brickellia Kellermanii* Greenm., 1734
- **† *Eupatorium ligustrinum* DC., 2238
- **† *E. Oerstedianum* Benth., 2243
- **† *E. Tuerckheimii* Klatt, 2237
- * † *Pluchea odorata* (L.) Cass., 2244
- **† *Senecio uspantanensis* (D. Sm.) Greenm., 2296

Connaraceae
- † *Connarus stenophyllus* Standl. & L. Wms., ex. desc., 1860

Cornaceae
- **† *Cornus disciflora* DC., 1702

Ericaceae
- † *Cavendishia crassifolia* (Benth.) Hemls., 2255
- **† *Gaultheria Hartwegiana* Klotzch, 1706, 2236
- **† *Lyonia squamulosa* M. & G., 1784, 1918, 2235
- †† *Sphyrospermum majus* Griseb., 1852
- **† *Vaccinium confertum* HBK., 1915, 2234

Flacourtiaceae
- † *Xylosma flexuosum* (HBK.) Hemsl., 1914

Guttiferae
- * †† *Ascyrum hypericoides* L., 1756, 2250
- **† *Clusia Salvinii* Donn. Smith, 1826a

Labiatae
- **† *Salvia rubiginosa* Benth., 2251

Lauraceae
- **† *Litsea glaucescens* HBK., 2227, 2239

Leguminosae
- **† *Calliandra grandiflora* (L'Her.) Benth., 1851
- **† *C. Houstoniana* (Mill.) Standl., 2273
- *Inga* sp., 1827
- **†† *Minosa albida* H. & B., 2357

Malpighiaceae
- †† *Bunchosia lanceolata* Turcz., 2321

Melastomaceae
- †† *Miconia acruginosa* Naud., 1779
- † *M. glaberrima* (Schlecht.) Naud., 1742
- † *M. mexicana* (Bonpl.) Naud., 1709
- *Monochaetum* sp., 1710

Myricaceae
- * †† *Myrica cerifera* L., 1723, 1753, 2233

Myrsinaceae
- *Ardisia* sp., 1744

Myrtaceae
- †† *Psidium guineense* Schwartz, 1699
- † *P. Oerstedianum* Berg, 1892, 1919

Onagraceae
- † *Hauya Heydeana* D. Sm., 2314

Palmaceae
- *Chamaedora* sp., 2256, 2293

Pinaceae
- **† *Juniperus comitana* Martínez, 1910

Polygalaceae
- **† *Polygala floribunda* Benth., 1700

Rhamnaceae
- **† *Ceanothus coeruleus* Lag., 2252

Rubiaceae
- **† *Bouvardia longiflora* (Cav.) HBK., 1781
- **† *Chiococca phaenostemon* Schlecht., 2295
- † *Palicourea mexicana* (Willd.) Benth., 1719

†† *Psychotria carthagenensis* Jacq., 2270
† *P. fruticetorum* Standl., 1745
* †† *Randia aculeata* L., 1776, 2336
† *Rondeletia stenosiphon* Hemsl., 2298
Saurauiaceae
† *Saurauia subalpina* D. Sm., 2299
S. sp., 2272
Simaroubaceae
**† *Picramnia quaternaria* Donn. Smith, 1732
Symplocaceae
* † *Simplocus Limoncillo* H. & B., 2257
Taxaceae
†† *Podocarpus Matudai* Lundell, 1917, 2300
Tiliaceae
**†† *Triumfetta grandiflora* Vahl, 2230
Verbenaceae
**† *Lippia chiapensis* Loes., 2246

3. HERBS AND VINES OF THE FOREST FLOOR:
Amaranthaceae
* †† *Iresine Celosia* L., 1871
Amaryllidaceae
**† *Agave* sp., 2347
† *Bomarea acutifolia* (L. & O.) Herb., 2302
**†† *Hypoxis decumbens* L., 2249
Araceae
† *Anthurium chiapense* Standl., 2334
† *A. fraternum* Schott, 1913
† *Monstera acacoyaguensis* Matuda, 1845
† *Philodendron guttiferum* Kunth., 1875
P. sp., 1846
† *Syngonium podophyllum* Schott, 1876
Begoniaceae
† *Begonia pinetorum* A. DC., 1721, 1859
B. sp., 2267
Bromeliaceae
Vriesia sp., 2306
Commelinaceae
†† *Callisia monandra* (Sw.) Schlecht., 2310
†† *Tripogandra elongata* (Mey.) Woodson, 1821, 2264
Compositae
** *Cacalia* sp., 2305
**† *Gnaphalium semiamplexicaule* DC., 1751, 2280
**†† *Heliopsis buphthalmoides* (Jacq.) Dunal, 1750, 2278
**† *Hieracium abscissum* Less., 1740
† *Liabum Bourgeaui* Hieron., 1780
† *Melampodium longifolium* DC., 2254
* † *Pinaropappus roseus* Less., 1760
†† *Piqueria trinervia* Cav., 2361
** *Spilanthes* sp., 2326
**†† *Stevia elongata* HBK., 2245
Droseraceae
* † *Drosera brevifolia* Pursch., 2304
Euphorbiaceae
* †† *Euphorbia brasiliensis* Lam., 1863
**† *E. lancifolia* Schlecht., 1711
**† *E. scabrella* Boiss., 2262
E. sp., 2366
**†† *Phyllanthus lathyroides* HBK., 1861
Gesneriaceae
† *Columnea guatemalensis* Sprague, 1773
† *Kohleria Deppeana* (S. & C.) Fritsch, 2260
Gramineae
**† *Panicum biglandulare* Scribn. & Smith, 2232, 2330
* † *P. xalapense* HBK., 1738
P. sp., 1887
* † *Setaria geniculata* (Lam.) Beauv., 1856
Guttiferae
* † *Hypericum gymnanthum* Engelm., 1900
Iridaceae
† *Orthrosanthus chimboracensis* var. *centro-americanus* Steyerm., 1720, 2303
Labiatae
**†† *Hyptis conferta* Pohl, 1754, 2279, 2359
* †† *H. mutabilis* (A. Rich.) Briq., 2274
**† *Salvia lavanduloides* HBK., 2248
**† *S. Mocinoi* Benth., 1713
**† *S. rubiginosa* Benth., 2251
S. sp., 1712, 1748, 2240, 2362, 2364
Leguminosae
†† *Eriosema crinitum* (HBK.) G. Don, 1731a
†† *E. diffusum* (HBK.) G. Don, 1731
* † *Crotalaria Purshii* var. *polyphylla* (Riley) Senn., 1743
** *Dalea* sp., 2354
**†† *Desmodium angustifolium* (HBK.) DC., 1739
D. sp., 2226, 2307
**† *Phaseolus spectabilis* Standl., 1826
†† *Teramnus labialis* (L. f.) Spreng., 1786
Lentibulariaceae
**† *Pinguicula lilacina* Scht. & Cham., 2261
**† *P. moranensis* HBK., 1725, 2259
Linaceae
**† *Linum Schiedeanum* S. & C., 1865
Liliaceae
* † *Smilax glauca* Walt., 1737, 1761, 1916
Lobeliaceae
**† *Lobelia Sartorii* Vatke, 1716, 1766, 1899
Lythraceae
**†† *Cuphea calophylla* C. & S., 2328
**†† *C. carthagenensis* (Jacq.) Macbr., 1887, 1901
**† *C. pinetorum* Benth., 1714
C. sp., 1873, 2327

**†† *Lythrum acinifolium* Sesse & Moc., 1872
Malvaceae
* †† *Sida rhombifolia* L., 1858
Melastomaceae
†† *Acisanthera quadrata* Juss., 2318
† *Arthrostemma parvifolium* Cogn., 1708, 1730
Ochnaceae
†† *Sauvagesia erecta* L., 2319
Onagraceae
† *Lopezia hirsuta* Jacq., 2360
* †† *Oenothera rosea* Ait., 1746
Orchidaceae
†† *Calianthe mexicana* Lindl., 1807
**† *Cranichis sylvatica* Rich. & Gal., 2283
Govenia sp., 2322
**† *Habenaria clypeata* Lindl., 2288
† *Sobralia macrantha* Lindl., 2308
**† *Spiranthes hemichrea* Lindl., 1724
**† *S. Xantholeuca* (Hort.) Rchb. f.
S. sp., 1752
Phytolaccaceae
**†† *Phytolacca icosandra* L., 1920
Polygalaceae
**† *Polygala aparinoides* Hook. & Arn., 1736, 2271, 2340a
**† *P. gracillima* Wats., 2358
P. sp., 2340
Pyrolaceae
* † *Chimaphila maculata* (L.) Pursh, 1879
**†† *Monotropa coccinea* Zucc., 1878, 2323
Ranunculaceae
**† *Ranunculus geoides* HBK., 2277
Rubiaceae
† *Crusea calocephala* DC., 1715, 1759
† *Declieuxia fruticosa* var. *mexicana* (DC.) Standl., 1741
†† *Relbunium hypocarpium* (L.) Hemsl., 1727
† *Hoffmannia Carlsoniae* Standl. & L. Wms., ex descr., 1747, 1874
* † *Spermacoce glabra* Michx., 1870
Sapindaceae
Paullinia sp., 1877
Scrophulariaceae
**† *Bacopa lacertosa* Standl., 1888
**† *Buchnera mexicana* Hemsl., 1864
**† *Castilleja arvensis* C. & S., 1867
†† *Russelia sarmentosa* Jacq., 2365
† *R. verticillata* HBK., 1749, 2241
Solanaceae
**† *Physalis gracilis* Miers., 2228
Umbelliferae
**†† *Hydrocotyle mexicana* Cham. & Schlecht., 1757
Urticaceae
**†† *Pilea microphylla* (L.) Liebm., 2320
Valerianaceae
**†† *Valeriana scandens* var. *Candolleana* (Gardn.) Muell., 1866
Vitaceae
**†† *Vitis tiliifolia* Humb. & Bonpl., 1829

4. PLANTS OF LAKES AND SHORES OF LAKES AND RIVERS:
Alismaceae
**† *Sagittaria angustifolia* Lindl., 1885
Asclepiadaceae
* †† *Asclepias curassavica* L., 1837
Compositae
**†† *Elephantopus mollis* HBK., 1881
* † *Spilanthes americana* var. *stolonifera* (DC.) A. H. Moore, 1894
Cyperaceae
* †† *Cladium jamaicense* Crantz, 1762
**†† *Dichromena ciliata* Vahl, 1718
* † *Fuirena simplex* Vahl, 1895
**† *Rhynchospora intermixta* C. Wright, 1897
Eriocauliaceae
**† *Eriocaulon Schiedeanum* Koern., 1883
Gentianaceae
† *Lisianthus quichensis* Donn. Smith, 1835
Halorrhagidaceae
* † *Proserpinaca palustris* L., 1884
Iridaceae
**† † *Sisyrinchium micranthum* Cav., 1855
S. sp., 1703
Labiatae
**† *Satureja xalapensis* (HBK.) Benth., 1882
Lentibulariaceae
* †† *Utricularia subulata* L., 1890
Loganiaceae
* †† *Cynoctonum Mitreola* (L.) Britt., 1893
Lythraceae
**†† *Cuphea mimuloides* Cham. & Schlecht., 1763
Nymphaeaceae
**†† *Nymphaea ampla* (Salisb.) DC., 1765
Orchidaceae
* †† *Bletia purpurea* (Lam.) DC., 1755, 2281
**†† *Epidendrum ibaguense* HBK., 1758
Plantaginaceae
**†† *Plantago hirtella* HBK., 1880
Polygalaceae
**†† *Polygala glochidiata* HBK., 1898
Polygonaceae
* † *Polygonum mexicanum* Small, 1701
Umbelliferae
**†† *Sanicula liberta* C. & S., 1785
Verbenaceae
**†† *Lippia stoechadifolia* (L.) HBK., 1707
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* †† *Xyris Jupicae* A. Rich., 1891

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Cyatheaceae
† *Cyathaea mexicana* C. & S., 2275
Equisetaceae
**†† *Equisetum myriochaetum* Schlecht. & Cham., 1839

Gleicheniaceae
† *Dicranopteris pectinata* (Willd.) Underw., 1834
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† *Hymenophyllum polyanthos* Swartz, 2332
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* †† *Lycopodium clavatum* L., 1889
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**† *L. Tuerckheimii* Maxon, 2276
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* †† *Osmunda regalis* var. *spectabilis* (Willd.) Gray, 1831, 1886
Polypodiaceae
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**† *A. feei* Moore, 1726
A. sp., 1833
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†† *Anthurium scandens* (Aubl.) Engler, 1820, 2331
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* † *E. nocturnum* Jacq.
**† *E. polybulbon* Sw.
**† *E. ramosum* Jacq., 2286
**† *E. rhyncophorum* Rich. & Gal., 2317
† *Jacquiniella leucomelana* (Reichb. f.), Schltr., 2325
† *Lycaste virginalis* (Sw.) Linden
† *Lockhartia Oerstedii* Reichenb. f., 1797
† *Maxillaria cucullata* (Lindl.) Hook
† *M. meleagris* Lindl.
† *M. Nagelii* L. O. Wms.
M. sp., 2333
† *Odontoglossum bictoniense* (Batem.) Lindl., 2291
† *O. convallarioides* (Schltr.) A. & C.
† *O. Egertonii* Lindl., 2337
**†† *Pleurothallis cardiothallis* Reichb. f., 2290
**†† *P. Grobyi* Batem, 2285
**†† *P. immersa* Linden & Reichb. f., 2284
**† *P. pansamalae* Schltr., 1800, 2289
**† *P. Tuerckheimii* Schltr.
P. sp., 1800
† *Scaphyglottis confusa* (Schltr.) A. & C., 1791
S. sp., 2292
**†† *Spiranthes speciosa* (J. F. Gmel.) A. Rich, 2282
† *Trichopilia tortilis* Lindl., 1806

Table 1 gives an analysis of the habits and distribution of the plants from the Montebello forest. Thirty-seven species, or 14.5 per cent of the total number of identified plants are found also in the United States. All are native in the United States except 3 adventive species, *Hyptis mutabilis, Sida rhombifolia* and *Pluchea odorata.* One large tree, *Liquidambar Styraciflua* (fig. 3), which extends from eastern United States to Florida and Texas and from Mexico to Nicaragua, is common at Montebello. None of the species of smaller trees is present in the United States. Four species of shrubs occur naturally in both regions: namely, *Symplocus Limoncillo,* which extends from southeastern United States to Texas, thence through Mexico to Central America; *Ascyrum hypericoides* and *Myrica cerifera,* which range as above, and in addition extend to the West Indies; and *Randia aculeata,* which is confined in the United States to southern Flor-

TABLE 1. *Analysis of plants collected in the Montebello forest*

	Total Species	* Species also in U. S.		** Genera, but not species, in U. S.		Species of genera not in U. S.	
		† Mex. & C. A.	†† Widely distr.	† Mex. & C. A.	†† Widely distr.	† Mex. & C. A.	†† Widely distr.
Large trees	9	1		8			
Smaller trees	13		4	3		7	3
Shrubs	45	1	(1 adv.) 5	23	2	11	4
Herbs							
Forest floor	87	7	(2 adv.)	29	13	21	12
Wet places	25	5	5	3	11	1	
Pteridophytes	30		8	18		4	
Epiphytes	47		1	11	6	18	11
Totals	256	14 (5.5%)	23 (9%)	95 (37.1%)	32 (12.5%)	62 (24.2%)	30 (11.7%)
Unidentified	45	(15% of the total of 301)					

ida, and is distributed through Mexico, Central America, the West Indies and Venezuela.

Of the 20 herbaceous species (exclusive of pteridophytes and epiphytes) which are native to Montebello and the United States, 12 are native to Mexico and to all or part of Central America, and the remainder extend into South America and/or the West Indies. Most of these herbaceous species are widely dispersed in eastern and southern United States, several extending westward to Texas. *Setaria geniculata* extends even to New Mexico and California. Half of the herbaceous species common to the Montebello forest and the United States grow in water, on the shores of lakes, or in swampy places, and half in dried places. *Crotalaria Purshii* of southern United States and Mexico is represented in the Montebello forest by its variety, *polyphylla. Spilanthes americana* var. *repens* occurs in the United States, but var. *stolonifera* is found at Montebello.

In addition to the identical species, 127 species (49.6%) in the Montebello forest are members of genera present also in the United States. The dominant large trees, *Quercus* (6 species) and *Pinus* (2 species), are all species different from those found in the United States (fig. 3). Most of the smaller trees belong to genera endemic to Mexico and Central America, only *Clethra, Cornus* and *Juniperus* having species present in the United States. *Godmania aesculifolia* extends to South America, and *Chamaedorea* and *Podocarpus* extend even more widely. Specimens referable to

FIG. 3. Trail through forest at Montebello. Trees 50–90 feet tall. *Liquidambar,* pines and oaks.

Clethra, Oreopanax, and *Zinowiewia* may prove to be new species, but are not described at present.

Twenty-five species of shrubs of the Montebello forest belong to genera found in the United States, whereas 15 species represent genera not found there. Since several species of some genera were collected, the number of genera found also in the United States is 21, the number not found there is 14. Most of the species of shrubs are native to Mexico and Central Amer-

ica. Specimens referable to *Connarus, Saurauia,* and *Ardisia* may prove to be new species, but require more study.

Excluding the genera of identical species, the pteridophytes and the epiphytes, 56 genera of herbaceous plants of the Montebello forest are also present in the United States. Thirty-two species of these genera are found only in Mexico and Central America, while 24 species range to South America and some to the West Indies as well. Of thirty-four genera not present in the United States, about two-thirds are Mexican and Central American, and about one-third are more widely distributed.

Thirty species of pteridophytes have been identified. Of these, *Lycopodium clavatum, Osmunda regalis* var. *spectabilis, Adiantum capillus-veneris,* and *Pteridium aquilinum* are widespread in the United States, but *Polypodium angustifolium, P. plumula, Pteris longifolia* and *Tectaria heracleifolia* are restricted to southern Florida. Tropical species of such genera as *Equisetum, Trichomanes, Asplenium, Cheilanthes, Dryopteris, Nephrolepis, Tectaria,* and *Selaginella,* all genera present in the United States, were found at Montebello. The only tree fern found was *Cyathaea mexicana.*

More than half of the collection of the epiphytic flora (47 species) is orchidaceous, but the 31 species listed represent only a small part of the total number of species present in the Montebello forest. Many were not in bloom and have not been identified. All, including one epiphytic species, *Epidendrum nocturum,* and one terrestrial, *Bletia purpurea,* which are found in southern Florida, are tropical species, about half of them native to Mexico and Central America and half more widely dispersed. The bromeliaceous flora at Montebello is even more extensive than the orchidaceous one, but collecting bromeliads was difficult and disappointing. Only seven species of *Tillandsia* and two of *Catopsis* were identified.

The following species, listed in the Flora of Guatemala ('46–'52) as endemic, can now be reported as occurring in Chiapas, Mexico:

Anthurium fraternum
Oreopanax Sanderianus
Gaultheria Hartwegiana
Columnea guatemalensis
Bacopa lacertosa
Phoradendron Aquilarii

In addition to those which may be new species, the following species have not yet been reported from Guatemala:

Sagittaria angustifolia
Anthurium chiapense
Lyonia squamulosa
Eriocaulon Schiedeanum
Monstera acacoyaguensis
Philodendron guttiferum
Wimmeria concolor
Pinaropappus roseus
Senecio parasiticus
S. uspantanensis
Melampodium longifolium
Drosera brevifolia
Pinguicula lilacina
Cuphea calophylla
Spiranthes Xantholeuca
Spermococe glabra
Buchnera mexicana
Smilax glauca
Lippia chiapensis

Mexico is not mentioned in the Flora of Guatemala as part of the range of the following:

Monstera pertusa
Brickellia Kellermanii
Eupatorium Oerstedianum
Rhynchospora intermixta
Quercus segoviensis
Lisianthus quichensis
Proserpinaca palustris
Hyptis conferta
Eriosema crinitum
Phaseolus spectabilis
Teramnus labialis
Phoradendron annulatum
Arthrostemma parvifolium
Epidendrum rhyncophorum
Peperomia maculosa
P. pililimba
Picramnia quaternaria

The following have been reported from other states of Mexico, but not from Chiapas:

Rondeletia stenosiphon
Psychotria fruticetum

Of the 256 identified species from Montebello, 14.5 per cent are identical with species in eastern and southern United States, 49.6 per cent are species of genera present in the United States, and 35.9 per cent belong to genera not found in the United States. Of these 66.8 per cent are Mexican and Central American species and 33.2 per cent are species of wide tropical distribution. Fifteen per cent of the total of 301 species are not yet identified.

Discussion. The Montebello forest is mentioned by Miranda and Sharp (1950) as Station C of the *Liquidambar*-forest type, but no data are given for it. Comparing 64 species, which they list from 6 other forests of mixed oak and *Liquidambar,* with the species found at Montebello, only 10 species are common to all those localities: namely, *Quercus polymorpha, Q. candicans, Cornus disciflora, Oreopanax xalapensis, Xylosma flexuosum, Kohleria deppeana, Vaccinium confertum, Chimaphila maculata, Smilax glauca,* and *Cyathea mexicana.*

Although the basis of the classification of some 200 plants which they collected in the 9 forest types which they studied is somewhat different from that used for the classification of the plants collected at Montebello, certain comparisons can be made, as follows:

	Miranda & Sharp	Carlson
Species common to Mexico and eastern United States	16%	14.5%
North temperate genera	37	64
Tropical genera	47	36
Species endemic to Mexico, or Mexico & Guatemala (or C. A.)	57	67
Species widely distributed	11	33

Steyermark (1950) lists 40 species of the Appalachian Uplands, Coastal Plain and Ozarks which are found also in Guatemala. Of these, only 4 species, *Liquidambar Styraciflua, Myrica cerifera, Ascyrum hypericoides, Proserpinaca palustris,* were found in the Montebello forest. However, spe-

cies of *Panicum, Rhus, Chimaphila* and *Monotropa,* different from those in Steyermark's list, were collected at Montebello.

According to Steyermark, the relationship of the Guatemalan flora and that of the Rocky Mountains and southwestern United States is generic rather than specific. Of 44 genera which he lists as common to the two regions, the following were found at Montebello: *Ranunculus, Linum, Castilleja, Stevia, Juniperus,* and *Pinaropappus.*

Steyermark states that the flora of Guatemala, especially that of the pine-oak forests is conspicuously a Mexican one. Six species which are listed as endemic to Guatemala are now known to be present at Montebello. Mexico is not listed in the Flora of Guatemala as part of the range of 17 species which can now be recorded for Mexico. Two species are new records for Chiapas.

Much more study will have to be made before conclusions can be drawn about the relationships of the flora of the high mountain areas of Mexico and Central America and that of the United States. If *Liquidambar* is an indicator of such related floras in the two regions, more detailed studies of the plants associated with *Liquidambar* in the series of forests extending along the eastern escarpment and in the high mesas of Mexico and Central America will be required. More careful studies of the distributions of the plants, as well as of their specific characteristics, must determine whether or not the species now reported as being present in all these regions are really identical species. The present study is merely the beginning of such work.

SUMMARY

1. Three hundred species were collected in a forest of pines, oaks, and *Liquidambar* at Montebello, Chiapas, Mexico. Of those identified, 14.5 per cent are species which appear to be identical with species found in eastern and southern United States, 49.6 per cent are species of genera represented by different species in the United States, and 35.9 per cent are species of genera not present in the United States. About 67 per cent are Mexican and Central American species and 33 per cent are species of wider tropical distribution.

2. A slightly smaller percentage of species identical with those in the United States (principally in the southeastern part) but a much larger percentage of genera which range to the United States were found in the Montebello forest than were found by Miranda and Sharp in similar forests.

3. About two-thirds of the plants in the Montebello forest and somewhat more than half of the plants in other forests containing pines, oaks, and *Liquidambar,* are endemic to Mexico and Central America. While 33 per cent of the plants in the Montebello forest were of wide tropical dis-

tribution, only 11 per cent of such plants were reported for other similar forests in Mexico.

4. Six species, listed as endemic to Guatemala, are now known to be present in Mexico. The range of 17 additional species can now be extended to southern Mexico, and that of 2 species, reported in Tabasco, can now be extended to Chiapas.

5. Much more study will have to be made before conclusions can be drawn about the relationships of the forests apparently indicated by the presence of *Liquidambar Styraciflua*.

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FUNGI ASSOCIATED WITH INTERNAL CONTAMINATION OF SUN-DRIED CHILE IN NEW MEXICO[1]

PHILIP J. LEYENDECKER, JR.[2]

The dried fruits of *Capsicum annuum* L. are used extensively as a condiment in Southwestern cookery. Commercially, the pods are known as chile (sometimes spelled chili) or red pepper. The pods are usually sun-dried to preserve the bright red color, since kiln-dried pods are very dark red and do not impart the desired red coloring characteristic of the sun-dried product.

New Mexico produces a considerable amount of sun-dried chile which commands a premium on the market because of its high pungency and bright red color. Within the last few years, New Mexico chile has been discriminated against because of the presence of molds within the dry pods. The Pure Food and Drug Administration inspectors have condemned shipments from New Mexico because of excessive internal mold. Often the fungal growth cannot be detected until the pods are broken open and examined (Leyendecker 1950). Figure 1 shows the appearance of the moldy pods when they are split open for examination. In the preparation of chile powder, if the percentage of infected pods is high, the ground product will be declared unfit for human consumption. This specialized crop constitutes a sizable income to New Mexico (Cockerell 1944), and the present study was undertaken to determine the species of fungi involved and their mode and time of entrance into the pods.

Materials and methods. Five 20-pod samples of sun-dried chile were annually selected at random from lots of chile produced in southern New Mexico in 1948, 1949, and 1950. The samples were examined in the laboratory by splitting open the pods and examining them for mold growth. Where applicable, direct isolations were made, purified, and grown on Czapek's nitrate agar for identification.[3]

Field plots were also established to determine the time and conditions under which the fungal contaminants became established in the curing pods. Two randomly-selected, 15-pod samples were tagged every two weeks, from August 10 until November 6 and allowed to cure naturally upon the plants during three growing seasons, 1948, 1949, and 1950. Only sound, red, suc-

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[3] *Fusarium* species were determined by Dr. W. C. Snyder, University of California.

culent fruits[4] were selected for experimentation. One series of each 15-pod sample served as a check, while the second series of 15 pods was punctured 15 times with a dissecting needle. The experimental pods were harvested

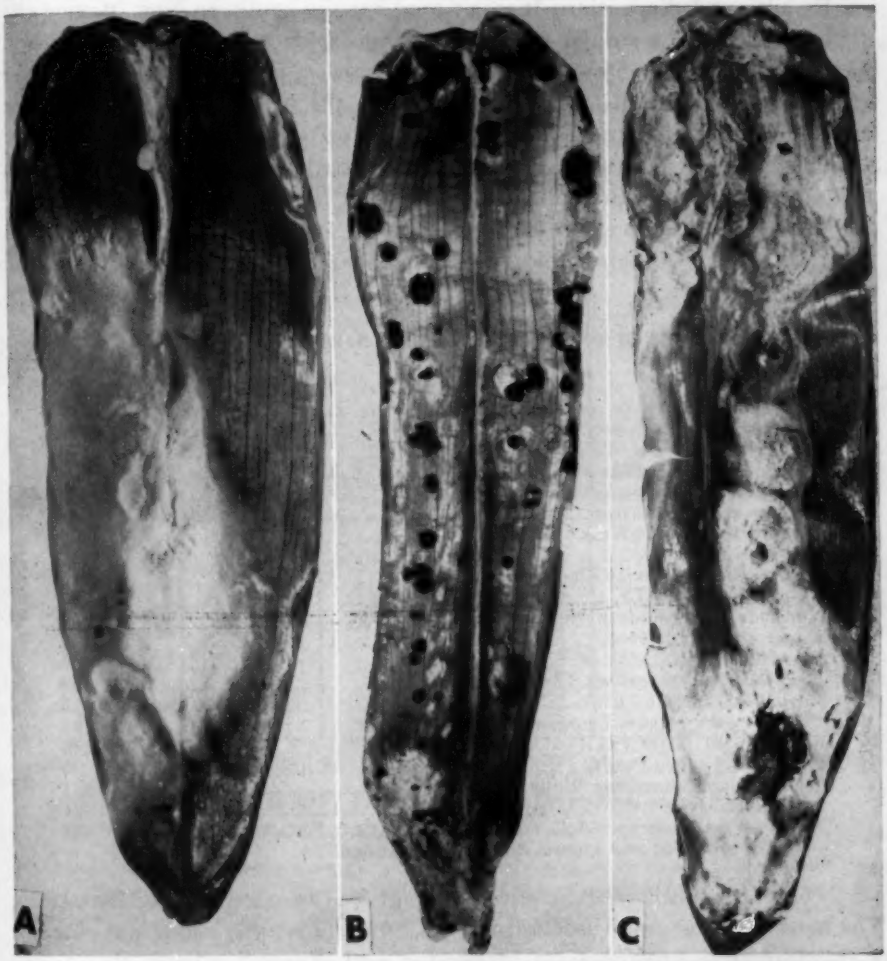

FIG. 1. Split pods of *Capsicum annuum* L., showing three of the most common fungi responsible for internal mold in New Mexico. A. *Fusarium roseum*. B. *Hormodendrum cladosporioides*. C. *Alternaria tenuis*.

when they all became dry, usually in early December. Each pod was then split open in the laboratory and examined for mold colonies. The prevalence of each fungus, time of first appearance, and the percentage of moldy or contaminated pods in each sample were recorded.

[4] *C. annuum* L., New Mex. Exp. Sta. selection known as College No. 6.

Some 200 progeny lines of *C. annuum* were also studied for morphological pod differences which might prevent the entrance of air-borne fungus spores following frost.

Results and discussion. It was found that in southern New Mexico the air-borne fungus inoculum potential in chile fields was very high. Usually, 95 to 100 percent of the punctured pods were contaminated each year (fig. 2). A fluctuation from year to year in the prevalence of the various air-borne fungi was noted. Two species of *Fusarium* were most prevalent in 1948, while two species of *Alternaria* accounted for 95 percent of the internal mold in 1949. In 1950, *Hormodendrum* was present in 60 percent of the pods examined. A complete listing of the fungi isolated and identified from internally contaminated pods of *C. annuum* during the three-year study follows:

FUNGI ISOLATED FROM SUN-DRIED CHILE

FUNGUS	PREVALENCE (Possible 840)
Alternaria solani (Ell. & G. Martin) Sor.	275
Alternaria tenuis Nees	484
Aspergillus niger v. Tiegh.	186
Aspergillus ochraceous Wilhelm	153
Aspergillus quadrilineatus Thom & Raper	63
Cladosporium herbarum Lk. ex Fr.	45
Curvularia lunata (Walk.) Boed.	306
Curvularia sp.*	15
Fusarium moniliforme Sheldon	518
Fusarium roseum Lk.	603
Hormodendrum cladosporioides (Fr.) Sac.	386
Mucor racemosus Fres.	154
Mucor sp.*	9
Penicillium chrysogenum Thom	30
Penicillium luteum Zukal	213
Phytophthora capsici Leonian	81
Rhizopus stolonifer (Ehr. ex Fres.) Lind.	145
Stachybotrys atra Corda	30
Stemphylium botryosum Wallr.	321
Stemphylium sp.*	27
Trichoderma lignorum (Jode) Harz.	32

* Does not fit any known species descriptions.

A total of 21 different species of fungi was isolated during the study. The most common fungi isolated were *Alternaria tenuis, Fusarium roseum, F. moniliforme, Stemphylium botryosum* and *Hormodendrum cladosporioides*. As many as three or four species of fungi were sometimes present in a cured pod. Such associations appeared to be totally at random, with no correlation between the occurrence of the various isolates.

Most of the fungi gained entrance to the red, succulent pods following the first killing frost, which usually occurred in mid-October. Figure 2, a three-year average, shows the results obtained in the study. Mold counts in sound (Check) pods were very low before frost, and immediately following frost the number of moldy pods increased appreciably. Frost injury resulted in a pulling away, at the calyx end, of the ovary wall from the seed

mass. This created a space for fungus spores to enter the pods, and the pod cavity provided excellent conditions for the germination and establishment of the fungi. Occasionally, infection occurred before frost if the pod wall had been injured by insect or mechanical means. Sometimes, *Alternaria tenuis* entered the pods by direct penetration of the ovary wall, at the calyx end, where atmospheric moisture had collected in the shoulder folds of the pod. In contrast, smooth-shouldered selection were not attacked by *Alternaria*.

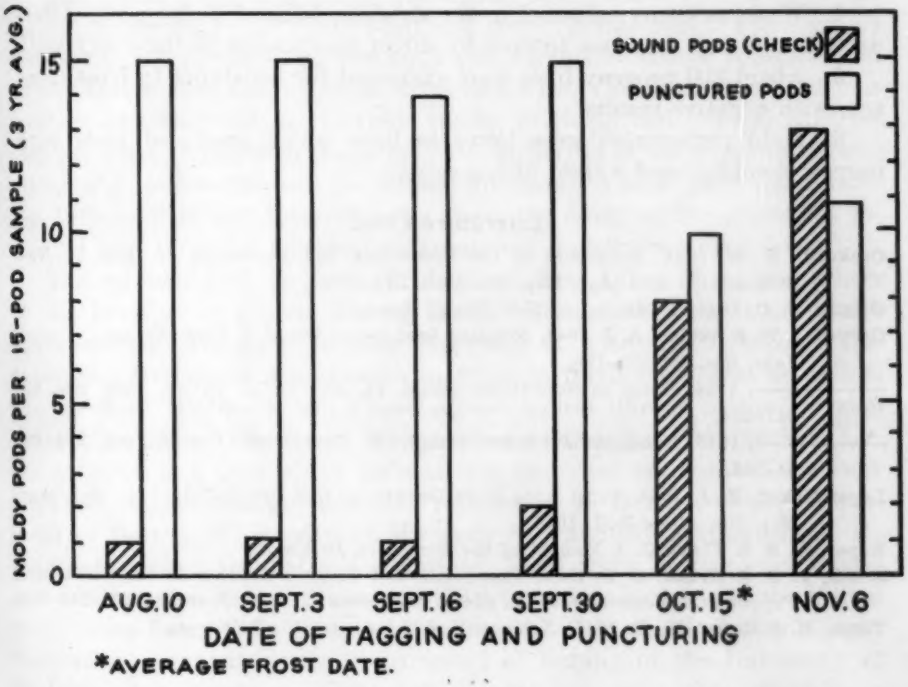

FIG. 2. Table showing average number of moldy pods in sound (check) and punctured 15-pod samples for a 3-yr. period (1948, 1949 and 1950). Note marked increase in moldy, sound pods (check) following frost on October 15.

Approximately 200 different progeny lines of *C. annuum* L. which were surveyed did not reveal a strain which showed any resistance to frost damage and subsequent internal contamination of the injured pods. It was noted, however, that a few lines which produced round, narrow-shouldered pods and a tight-fitting calyx had fewer moldy pods than did the normal wide-shouldered, loose-calyx fruited lines.

SUMMARY

1. The marketing of sun-dried chile produced in New Mexico is seriously handicapped by the presence of molds within the cured pods.

2. A three-year study revealed that: a. 21 different fungi were responsible for internal pod contamination. b. The most common internal contamination were two species of *Fusarium*, two species of *Alternaria*, and one species of *Hormodendrum*. c. Prevalence of the various fungi varied from year to year.

3. The fungi usually gained entrance to the red succulent pods following damage by frost when the ovary wall pulled away from the seed mass allowing for the entrance of fungus spores.

4. When moisture collected in the shoulder folds of fleshy pods, *Alternaria tenuis* and *A. solani* entered by direct penetration of the ovary wall.

5. About 200 progeny lines were examined for resistance to frost damage, with negative results.

6. Mold percentages were lower in lines which produced pods with narrow shoulders and a tight-fitting calyx.

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NEW ENTITIES IN NORTH AND MIDDLE AMERICA ERAGROSTIS (GRAMINEAE)

LEROY H. HARVEY

The genus *Eragrostis* has a world-wide distribution with most of the species occurring in the subtropical and subtemperate zones. There are 58 native and 16 introduced species known in North and Middle America. Ten of the native ones also occur in South America. The genus has a curious mixture of stable and polymorphic species in North and Central America and the West Indies with the latter most numerous in the perennial group allied to *E. intermedia* and the annual group allied to *E. pectinacea*. During 1938 to 1942 and intermittently since, the study of the genus has indicated that there are five well differentiated undescribed taxa.

The valuable help of Jason R. Swallen, Mrs. Agnes Chase and others of the Division of Plants, United States National Museum is gratefully acknowledged. The very valuable collection of holotypes, isotypes, paratypes and fragments of and notes on types in foreign herbaria as well as the excellent Hitchcock and Chase Agrostological library in the Division greatly facilitated this study. The curators and staffs of the various herbaria visited and from which material was borrowed are thanked for their kind cooperation. The guidance of Professor H. H. Bartlett of the Department of Botany, University of Michigan is gratefully acknowledged. He kindly furnished the Latin descriptions. Field work in northern Mexico and southwestern United States and visits to various herbaria in the United States were financed by means of the Emma J. Cole and S. Rudolph Light Fellowships granted by the Department of Botany of the University of Michigan.

A preliminary revision of the 73 species of the genus known in 1948 to occur in North and Central America and the West Indies is given in a doctoral dissertation submitted to the Department of Botany, University of Michigan. This revision includes detailed descriptions, the known distribution, synonymy, excluded species and a catalog of the specimens studied. This revision is available on microfilm (Harvey 1948). One additional introduced species, *E. lehmanniana*, is included in a treatment of species of the genus occurring in Arizona (Harvey 1951).

Because the publication of new species by microfilming of manuscripts is no longer effective publication, Article 39, International Code of Botanical Nomenclature (Lanjouw 1952), the following descriptions are given to validate the names used.

Eragrostis yucatana L. H. Harvey sp. nov. Planta perennis. Culmi rigidi, erecti, 40 vel 75 cm. alti. Vaginae glabrae apicibus pilosis marginum exceptis. Laminae involutae, attenuatae, suprene disperse pilosae ad basin, 10 vel 15 cm. longae, 1–1.5 mm. latae. Paniculae strictae, interruptae solum ad basin, 15 vel 25 cm. longae, 1.5–2 cm. latae, ramis e basi floriferis, rigide ascendentibus vel appressis, 2 vel 5 cm. longis, ad axillas glabris. Pedicelli non longiores quam 0.8 mm. Spiculae ovatae, acutae, valde compressae, 7 vel 9 mm. longae, 2.2–2.8 mm. latae, 12- vel 20-floriferae, rachilla disarticulante. Glumae inaequales, anguste ovatae, acutae. Lemmata ovata, acuta, 2.2–2.4 mm. longa, nervis lateralibus firmissimis. Paleae lemmata aequantes, breviter persistantes temperius caducae. Fructus oblongi, striati, 0.8 mm. longi, 0.4 mm. lati.

Specimen typicum legit J. R. Swallen n. 2933 (US 1,537,194), 11–15, Aug. 1933 in locis aridis secus viam prope "Progreso, Yucatán," in Repubica Mexicana.

Species nova *E. oxylepidi* affinis etiamque *E. Ekmanii* et probabiliter *E. eucamptae;* differt a priore paniculis strictis, a *E. Ekmanii* et *E. eucamptae* panicula solum basi interrupta spiculisque haud fasciculatis.

Perennial. Clums tufted, stiffly erect or ascending, branching at the base, 40 to 75 cm. tall. Sheaths shorter than the internodes, those of the innovations overlapping, pilose at the apex of the margins, rounded on the back. Ligule a dense row of white hairs about 0.3 mm. long. Blades involute, attenuate, glabrous below, scabrous with scattered supraligular hairs above, 10 to 15 cm. long, 1 to 1.5 mm. wide. Panicles strict, interrupted at the base, densely flowered, 15 to 25 cm. long, 1.5 to 2 cm. wide, the rachis scabrous, the branches appressed or closely ascending, floriferous to the base, scabrous, slender, stiff, the lower 2.5 to 5 cm. long, the upper about 2 cm. long, the axils glabrous. Pedicels much shorter than the spikelets, scabrous, appressed, 0.2 to 0.8 mm. long. Spikelets ovate, acute, strongly compressed, greenish-straw-colored, reddish-brown tinged, nearly sessile, appressed to the branches, 7 to 9 mm. long, 2.2 mm. to 2.8 mm. wide, 12- to 20-flowered, the rachilla disarticulating. Glumes narrowly ovate, acute, compressed, keeled, scabrous on the keel, the first 1.8 to 2 mm. long, about 0.4 mm. wide, the second 2 to 2.2 mm. long, about 0.8 mm. wide. Lemmas ovate, acute, usually abruptly so, compressed, keeled, scabrous on the keel, strongly imbricate, 2.2 to 2.4 mm. long, about 1.2 mm. wide, the lateral nerves very strong. Paleas about as long as the lemmas and persistent for a short while after their fall, ciliolate on the strong keels, convex on the back below. Grains oblong, translucent, striate, reddish-brown, about 0.8 mm. long and 0.4 mm. wide.

In arid sandy soil in Yucatán.

MEXICO. Yucatán: Minatitlan, *J. G. Smith* 564 (MINN); Progresso, *J. R. Swallen* 2933 (MICH; US: type); San Anselmo, *G. F. Gaumer* 1207 (F, GH, MINN, NY); Chichankanab, *G. F. Gaumer* 2249 (F, GH, NY).

Eragrostis glandulosa L. H. Harvey sp. nov. Planta annua. Culmi erecti vel ascendentes, 70 vel 200 cm. alti. Vaginae apice marginum hispidae, marginibus propiis papillosi-hispidis, carina nervisque lateralibus foveolatis, foveolis multiglandulosis. Laminae planae vel plicatae, subtus scabrae, superne scabrae et sparse papillosi-hispidae, 35 vel 50 cm. longae, 6 vel 14 mm. latae. Paniculae late ovatae, apertae, decompositae, 35 vel 45 cm. longae, 20 vel 35 cm. latae, ramis gracilibus, ascendentibus vel diver-

gentibus, multiramulosis, 10 vel 15 cm. longis, ad axillas glabris. Spiculae lineari-lanceolatae vel ovatae, viridiuscule hyalinae vel stramineae et purpureitinctae, 2.2–5 mm. longae, 1 vel 2 mm. latae, 2-vel 8-floriferae; rachilla non disarticulante. Glumae hyalinae, acuminate lanceolatae vel acute ovatae, 1.2–1.6 mm. longae. Lemmata ovata, acuta, 1.4–1.8 mm. longa, nervis lateralibus conspicuis. Paleae hyalinae, lemmata aequantes, persistentes. Fructus breves, cylindrici, striati, circa 0.8 mm. longi et 0.4 mm. lati.

Specimen typicum legit Ynes Mexia n. 8774 (US 1,724,746) ad altitudinem 312 m. in litore fluminis prope locum "Barranca de la Suriana, Sierra Madre del Sur, north of the Río Balsas, Temisco, Distrito Adama, Guerrero," in Republica Mexicana.

Species *E. hirsutae* et *E. capillari* affinis, sed differt foveolis glandulosis in vaginarum nervis.

Annual. Culms stout, branching at the base, erect or ascending, 70 to 200 cm. tall. Sheaths somewhat compressed, longer than the internodes, hispid at the apex of the margins, sometimes part way around the collar, usually papillose-hispid down the margins, the keel and other nerves with many small glandular pits. Ligule a dense row of white hairs about 1 mm. long. Blades flat, folded or subinvolute, midnerve heavy, scabrous on both surfaces, scattered papillose-hispid above the ligule, 35 to 50 cm. long, 6 to 14 mm. wide. Panicles broadly ovoid, open, loosely flowered, 35 to 40 cm. long, 20 to 35 cm. wide, the rachis scabrous towards the tip, the branches slender, flexuous, ascending to spreading, fragile, decompound, 10 to 15 cm. long, the axils glabrous. Pedicels slender, flexuous, fragile, spreading. 3 to 10 mm. long. Spikelets linear-lanceolate to ovate, straw-colored and greenish- to purplish-tinged, 2.2 to 5 mm. long, 1 to 2 mm. wide, 2- to 8-flowered, the rachilla not disarticulating. Glumes hyaline, compressed, keeled, scabrous on the keel, the first acuminate, lanceolate, 1.2 to 1.6 mm. long, about 0.4 mm. wide, the second acute, ovate, 1.2 to 1.6 mm. long, about 0.8 mm. wide. Lemmas ovate, acute to subacute, scabrous on the keel, 1.4 to 1.8 long, about 1.2 mm. wide, loosely imbricate, the lateral nerves conspicuous. Paleas hyaline, as long as the lemmas, persistent, slightly convex on the back, scabrous or glabrous on the keels. Grains short, cylindric, reddish-brown, somewhat flattened, translucent, striate, about 0.8 mm. long and 0.4 mm. wide. Anthers yellowish- or purplish-tinged, cylindric, 0.8 to 1 mm. long, about 0.3 mm. wide.

Sandy soil along streams, in ravines or thickets in partial shade from Central Mexico to northern Central America.

MEXICO. Jalisco: San Nicolás, *A. S. Hitchcock* 7234 (US). Morelos: Xochiltepec, *E. Lyonnet* 2620 (US). Guerrero: Temisco, *Y. Mexia* 8774 (US: type); Achotla, *B. P. Reko* 5017 (US)

CENTRAL AMERICA. Guatemala: Pastores, Dept. Sacatepéquez, *P. C. Standley* 60796 (US); *E. T. Heyde* and *E. Lux* 6270 (US). El Salvador: San Salvador, *A. S. Hitchcock* 8954 (MICH, US).

Eragrostis oreophila L. H. Harvey sp. nov. Planta perennis. Culmi caespitosi, erecti ex basi nodosa, altitudine 30–75 cm. Vaginae mediam internodiorum attingentes, glabrae apicibus pilosis marginum exceptis. Laminae attenuatae, convolutae, subtus glabrae, superne dense pilis supra ligulam vestitae, 4 vel 10 cm. longae, 1 vel 2 mm. latae. Paniculae pyramidales, apertae, 10 vel 30 cm. longae, 10 vel 18 cm. latae, ramis ascendentibus vel divergentibus, inter se distantibus, solitariis vel binis, 5 vel 15

cm. longis; axillis raro pilosis. Spiculae lanceolatae, 4 vel 6 mm. longae, 2–2.2 mm. latae, 7- vel 9-floriferae. Glumae acuminatae, 1.6–2 mm. longae. Lemmata ovata, acuta, 2–2.2 mm. longa, nervis lateralibus inconspicuis. Paleae quam lemmata paulum breviores. Fructus breves, cylindrici, striati, circa 0.8 mm. longi et 0.4 mm. lati.

Specimen typicum: V. H. Chase n. 7223½ (US 1,763,115), Jun. 29, 1939, in declivitate saxosa ad altitudinem 1500 m. prope "Jacala, Hidalgo," in Republica Mexicana.

Species *E. intermediae* et *E. trichocoleae* affinis, sed differt a prima paniculis simplicibus, latitudine spicularum et axillis raro pilosis. A secunda differt vaginis glabris et floseulis numerosis.

Perennial. Culms tufted, erect or ascending from a knotty base, sometimes geniculate at the lower nodes, glabrous, 30 to 75 cm. tall. Sheaths overlapping at the base, less than half the length of the internodes above, glabrous on the rounded back, pilose on the margins near the apex. Ligule a dense row of white hairs about 0.4 mm. long. Blades short, attenuate, convolute, usually ascending, glabrous below, with dense supraligular hairs above (at least on the lower blades and on those of the innovations) 4 to 10 cm. long, 1 to 2 cm. wide. Panicles pyramidal, open, usually simple, 10 to 30 cm. long, 10 to 18 cm. wide, the rachis sometimes flexuous, scabrous on the upper half, the branches ascending to spreading, usually simple, distant, solitary or in pairs, slender, flexuous, scabrous, 5 to 15 cm. long, the lowest commonly much shorter than those just above, the axils rarely sparsely pilose. Pedicels ascending or appressed, scabrous, slender, longer than the spikelets, 5 to 7 mm. long. Spikelets lanceolate, compressed, grayish-green, 4 to 6 mm. long, 2 to 2.2 mm. wide, 7- to 9-flowered, the rachilla not disarticulating. Glumes hyaline, scabrous on the keeled and compressed tip, the first acuminate, lanceolate, 1.6 to 1.8 mm. long, about 0.4 mm. wide, the second acuminate, ovate, 1.6 to 2 mm. long, about 0.8 mm. wide. Lemmas acute, ovate, loosely imbricate, hyaline at the tip and part way down the margins, 2 to 2.2 mm. long, about 1.2 mm. wide, the lateral nerves inconspicuous. Paleas hyaline, from eight-tenths to nearly as long as the lemmas, persistent, ciliolate on the keels, evenly convex on the back. Grains short, cylindric, flattened, reticulate, translucent, reddish-brown, about 0.8 mm. long and 0.4 mm. wide.

On mountain sides from 1000 to 2000 m. in Mexico.

MEXICO. Baja California: Sierra de la Laguna, *T. S. Brandegee* 28 (US). Nuevo León: Galeana, *Mary Taylor* 77 (MICH). Hidalgo: Jacala, *V. H. Chase* 7223½ (GH, US: type); Jacala, *Mrs. M. T. Edwards* 1742 (TEX, US).

Eragrostis praetermissa L. H. Harvey sp. nov. Planta perennis. Culmi caespitosi, rigidi, erecti vel ascendentes ex basi nodosa, circa 70 cm. alti. Vaginae papillosi-hispidae. Laminae planae, subtus papillosi-hispidae, superne glabrae, 20 vel 25 cm. longae, circa 5 mm. latae. Paniculae lanceolatae, apertae, strictae, 35 vel 40 cm. longae, 10 vel 15 cm. latae, ramis ascendentibus vel divergentibus, solitariis vel oppositis, 6 vel 12 cm. longis, ad axillas sparse pilosis. Spiculae ovate lanceolatae, plumbeae, 4 vel 6 mm. longae, 1.8–2.4 mm. latae, 5- vel 9-floriferae, rachilla disarticulante. Glumae acuminate lanceolatae, subaequales. Lemmata ovata, acuta, 2–2.2 mm. longa, nervis lateralibus inconspicuis. Paleae lemmata aequantes. Fructus breves, cylindrici, applanati, reticulati, circa 0.8 mm. longi et 0.4 mm. lati.

Specimen typicum legit von Türckheim n. 1292 (US 821,939), Jul. 1887, in rupibus prope "Santa Rosa, Dept. Baja Verapaz, Guatemala." Species

E. Tracyi, *E. tricholeae* et *E. oreophilae* affinis, sed differt a prima et tertia vaginis papillosi-hispidis etiamque paniculis multo longioribus; a secunda differt paniculis longioribus, apertioribus, et laminis longioribus latioribusque.

Perennial. Culms tufted, stiffly erect or ascending from a knotty base, glabrous, about 70 cm. tall. Sheaths overlapping, rounded on the back, papillose-hispid, more densely so towards the summit. Ligule a dense row of white hairs about 0.2 mm. long. Blades flat, short-attenuate at the tip, glabrous below, papillose-hispid above, sometimes sparsely so, 20 to 25 cm. long, about 5 mm. wide. Panicles lance-ovoid, open, stiff, 35 to 40 cm. long, 10 to 15 cm. wide, the branches ascending to spreading, flexuous, slender, scabrous, solitary or opposite, occasionally verticillate, usually somewhat distant, 6 to 12 cm. long, the axils pilose. Pedicels slender, ascending to spreading, shorter than the spikelets, 2 to 4 mm. long. Spikelets ovate-lanceolate, plumbeous, compressed, 4 to 6 mm. long, 1.8 to 2.4 mm. wide, 5- to 9-flowered, the rachilla disarticulating. Glumes acuminate, compressed and keeled, scabrous on the keel, the first 1.4 to 1.6 mm. long, about 0.4 mm. wide, the second 1.6 to 1.8 mm. long, about 0.8 mm. wide. Lemmas ovate, acute, loosely imbricate, 2 to 2.2 mm. long, about 1.2 mm. wide, the lateral nerves conspicuous. Paleas as long as the lemmas, hyaline, evenly convex on the back, ciliolate on the keels. Grains short, cylindric, flattened, reticulate, translucent, reddish-brown, about 0.8 mm. long and 0.4 mm. wide.

In the mountains of Mexico and Central America.

MEXICO. Michoacán: Jacuaro, *A. S. Hitchcock* 6956 (US)

CENTRAL AMERICA. Guatemala: Santa Rosa, Dept. Baja Verapaz, *H. von Türckheim* 1292 (US: type).

Eragrostis perplexa L. H. Harvey sp. nov. Planta annua. Culmi caespitosi, erecti vel ascendentes, plerumque foveolis glandulosis dispersis infra internodia inferiora, 15 vel 45 cm. alti. Vaginae multiglandulosae in carina et nervis lateralibus, ad apicem marginum pilosae. Laminae planae vel involutae, subtus glabrae, superne scabrae. Paniculae oblongae vel ovatae, plerumque in vagina summa inclusae, apertae, gracillimae, 15 vel 25 cm. longae, 5 vel 10 cm. latae, ramis ascendentibus vel divergentibus, tenuissimis sed vix capillariis, plerumque multiglandulosis, 5 vel 8 cm. longis, axilis inferioribus pilosis. Spiculae lineares vel lineari-lanceolatae, 5–7.5 mm. longae, 0.8–1 mm. latae, 7- vel 11-floriferae, rachilla no disarticulante. Glumae valde inaequales. Lemmata ovata, acuta, 2–2.2 mm. longa, nervis lateralibus conspicuis. Paleae lemmatibus breviores. Fructus ellipsoidei, circa 0.8 mm. longi et 0.3 mm. lati.

Specimen typicum legit W. L. Tolstead sine numero (US 1,645,027), 30 Aug. 1935, e loco alkalino in "Mellete Co., South Dakota."

Species *E. pilosae* affinis, sed different praecipque foveolis glandulosis numerosis in vagina, rhachi ramisque paniculae.

Annual. Culms tufted, slender, erect or ascending, sometimes decumbent at the base and geniculate at the lower nodes, branching at the base and sometimes above, usually with scattered glandular pits below at least the lower nodes, 15 to 45 cm. tall. Sheaths shorter than the internodes overlapping at the base, usually compressed and keeled, usually with many scattered glandular pits on the keel and commonly on the other nerves, pilose at the apex of the margins, the lower ones sometimes tinged with reddish-purple. Ligule a dense row of white hairs about 0.2 mm. long.

Blades flat to involute, attenuate, sometimes with scattered glandular pits on the midrib otherwise glabrous below, scabrous above, 10 to 15 cm. long, 1.5 to 2.5 mm. wide. Panicles oblong to ovoid, usually somewhat enclosed in the upper sheath, occasionally long exeeted, 15 to 25 cm. long, 5 to 10 cm. wide, the rachis usually with scattered glandular pits and scabrous, the branches ascending to spreading, very slender, flexuous, scabrous, usually with scattered glandular pits, verticillate or opposite, the verticils somewhat distant, 5 to 8 cm. long, the lower axils pilose. Pedicels appressed to ascending, capillary, usually longer than the spikelets, sometimes with glandular pits, scabrous, 2.5 to 8 mm. long. Spikelets linear to linear-lanceolate, somewhat compressed, dull light green or purplish-tinged, 5 to 7.5 mm. long, 0.8 to 1 mm. wide, 7- to 11-flowered, the rachilla not disarticulating. Glumes acuminate, hyaline, unequal, the first 0.2 to 0.4 mm. long, about 0.2 mm. wide, the second 1 to 1.2 mm. long, about 0.4 mm. wide. Lemmas ovate, acute, scabrous on the upper part of the keel, rounded on the back below, somewhat keeled towards the tip, very loosely imbricate, sometimes scabrellous on the upper part of the back, 2 to 2.2 mm. long, about 0.8 mm. wide, the lateral nerves conspicuous. Paleas six-to-eight-tenths as long as the lemmas, hyaline, evenly convex on the back, ciliolate on the keels, deciduous. Grains subellipsoidal, smooth, translucent, reddish-brown, about 0.8 mm. long and 0.3 mm. wide.

Low alkaline areas and buffalo wallows from North Dakota to Texas. UNITED STATES. North Dakota: Mandan, *J. R. Swallen* 5850 (US). South Dakota: Mellett Co., *W. L. Tolstead*, Aug. 30, 1935 (U.S: type). Minnesota: Pipestone, *S. E. Fellows* 4 (MINN). Nebraska: Callaway, *J. M. Bates* 2414 (GH, US). Kansas: Wallace Co., *Pl. Kan.* 931 (MO, US, WYO). Colorado: Saguache Creek, *J. Wolf* 1146 (US); Alamosa, *C. L. Shear* 867 (GH, NY, US). Texas: Texline, *D. Griffiths* 5637 (US).

SUMMARY

1. Study of the species of the grass genus *Eragrostis* has shown that there are the following five undescribed taxa in North and Middle America: *E. yucatana*, allied to *E. oxylepis* and *E. ekmanii*, known only from Yucátan; *E. glandulosa*, allied to *E. hirsuta*, known from southern Mexico and northern Central America; *E. oreophila*, allied to *E. intermedia* and *E. trichocolea;* known from the Mexican plateau and southern Baja California; *E. praetermissa*, allied to *E. tracyi*, *E. trichocolea* and *E. oreophila*, known from Michoacán, Mexico and Guatemala; and *E. perplexa*, allied to *E. pilosa*, known from the great plains regions of the United States.

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BULLETIN OF THE TORREY BOTANICAL CLUB
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PRODUCTION OF AERIAL ARTHROSPORES BY HARPOSPORIUM BYSMATOSPORUM

CHARLES DRECHSLER[1]

The curious nematode parasite I described several years ago (Drechsler 1946) under the binomial *Harposporium bysmatosporum* was more recently found developing abundantly in some maizemeal-agar plate cultures which after being overgrown with mycelium of *Pythium debaryanum* Hesse had been further planted with small quantities of decaying vegetable detritus collected on December 20, 1952, near LaPlace, Louisiana. It subsisted altogether by destroying numerous eelworms referable to a species of *Rhabditis* closely similar to the species that served as host in the earlier cultures prepared with decaying straw from Colorado. The more proximal segments of the procumbent hyphae extended from infected animals commonly bore grouped phialides (fig. 1, A, a–c) on whose slender sterigmata were borne conidia of distinctive humerus-like profile (fig. 1, B). When one of these conidia become lodged in the stoma of a host eelworm (fig. 1, C) it pushed into the fleshy tissues of the head a narrow germ tube from which developed an assimilative mycelium that again produced procumbent hyphae with grouped phialides (fig. 1, C, a–c) and conidia (fig. 1, D), thereby repeating the cycle made known in the original account of the fungus. In many infected animals the parasite showed no other kind of reproduction.

Sometimes, however, a procumbent hypha after putting forth phialides from its proximal segments would grow upward into the air at noticeably increased width and then would ramify several times at relatively wide angles. The axial prolongation (fig. 1, A, d) and the branches (fig. 1, A, e–h) soon were divided into cylindrical segments, which later became rounded at both ends. Chains of colorless rod-shaped spores were thus formed, the number of spores in a chain varying commonly from 3 to 6. Where ample nourishment was provided in a full-grown eelworm the accessory reproductive apparatus often included 10 to 15 catenulate branches. Sooner or later the stiffly ramifying chains became broken up under the jostling of large nematodes or of mites and springtails. The disjointed arthrospores (fig. 1, E) left strewn about on the substratum commonly measured 10 to 20 μ in length and 2.3 to 2.7 μ in width. They appeared to be filled with protoplasm of nearly homogeneous texture, though in many instances their contents seemed slightly denser at the ends than in the middle. They remained for weeks without evident change, neither germinating nor degenerating.

[1] Mycologist, United States Department of Agriculture, Plant Industry Station, Beltsville, Maryland.

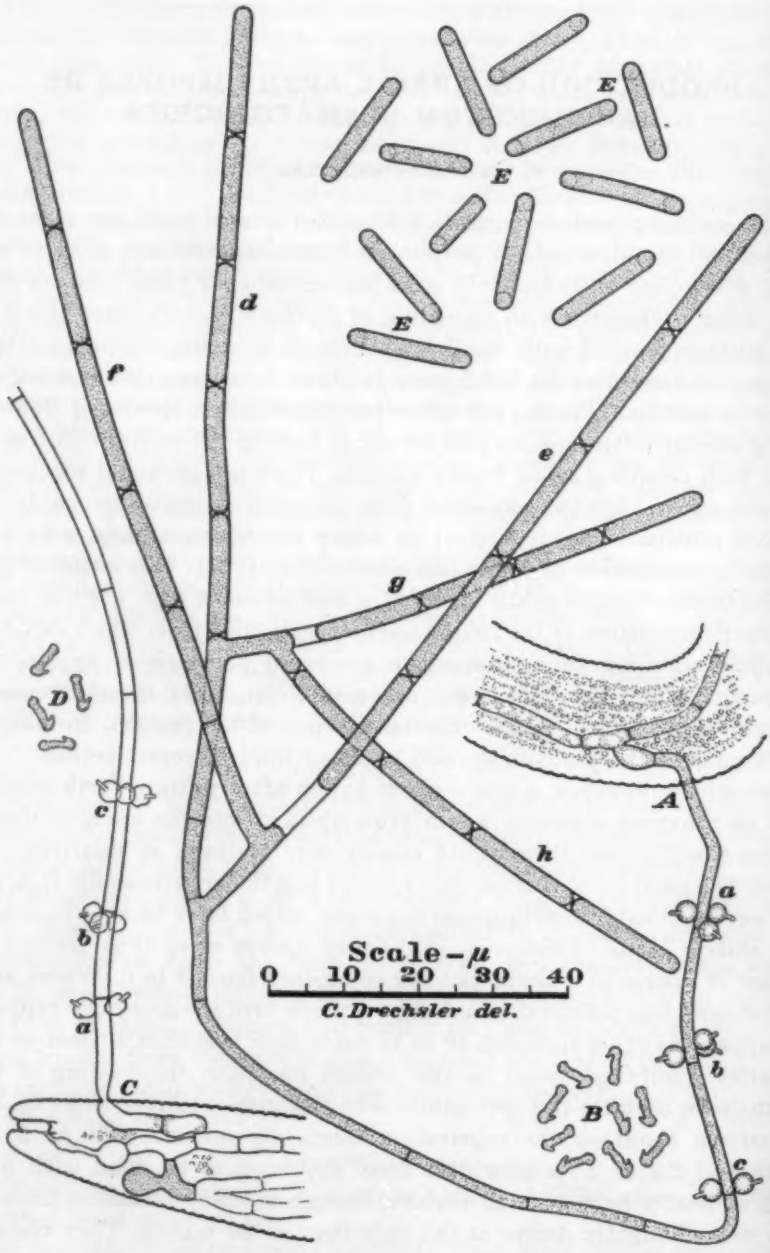

FIG. 1. *Harposporium bysmatosporum;* drawn at a uniform scale of magnification with the aid of a camera lucida; ×1000 throughout. A, Middle portion of host nematode (*Rhabditis* sp.) showing assimilative filament that has put forth externally a procumbent

While their inert behavior would seem to betoken somewhat greater capacity for enduring unfavorable conditions than could be expected in the small conidia borne on the phialides, their different structure as well as their different manner of origin removes them from any close parallelism with the durable chlamydospores formed intercalarily in the assimilative hyphae of the widespread congeneric species *Harposporium anguillulae* Lohde *sensu* Zopf (1888).

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hypha which besides forming 3 groups of phialides, a–c, on its proximal segments has grown out distally to produce 5 aerial chains, d–h, of cylindrical arthrospores. B, Nine detached conidia produced on the phialides shown in A, a–c. C, Anterior portion of host nematode (*Rhabditis* sp.) showing connection of assimilative mycelium with empty membrane of condium lodged in stoma; from the mycelium was extended a procumbent hypha with 3 groups of phialides, a–c, now represented only by their membranous envelopes. D. Four conidia from the phialides shown in C, a–c. E, Detached rod-shaped arthrospores coming from break-up of aerial chains.

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TEMPERATURE EFFECTS UPON THE RATE OF NUCLEAR DIVISION IN ROOT TIPS OF *TRILLIUM SESSILE* L.

PAUL C. BAILEY

Plants are continually subjected to the variabilities of a complex set of environmental factors which greatly influence every physiological process within the plant. Among these physiological processes influenced by environmental conditions is growth, and perhaps one of the greatest, single factors exerting an effect upon the growth processes, as well as other physiological reactions of the plant, is temperature. The temperature pattern of the plant's environment not only influences the rate of growth but often determines whether or not a plant can survive in a given habitat. In considering temperature influences upon growth it is usually customary to consider a minimum, a maximum, and an optimum temperature. These temperatures are subject to considerable variation with different species and to variations within the same species depending upon the stage of development, the physiological condition of the plant, and the time and rate of exposure. Arctic and alpine species may grow at the freezing point or at temperatures slightly below, and their optimum growth temperature may be as low as 10° C. Most temperate species do not grow below 5° C., their optimum temperature being around 30° C., with a maximum temperature no higher than 40° C. Tropical and subtropical species show growth temperatures higher than for temperate species.

The upper or lower temperature limits which plants or plant organs can withstand vary greatly depending upon the species and upon their capacity for heat resistance and cold resistance. The temperatures at which plants or plant organs fail to survive are usually several degrees above or below those at which growth ceases.

If growth in plants or plant organs is influenced by temperature then the rate of nuclear division must also be influenced by temperature. It has been generally accepted that the rate of growth in any part of the plant is proportional to the number of cells dividing in that region and to increase in cell size following cell division. It was the primary purpose of this study to determine the influence of temperature upon growth in the root tips of *Trillium sessile* L., and to determine the influence of temperature upon the rate of nuclear division within these root tips. An attempt was made to correlate the number of dividing nuclei with actual increase in length of the root tip at given temperatures. Also, the effects of various temperatures upon the mitotic figures were noted.

Materials and methods: Fresh growing root tips of *Trillium sessile* L. were used as a source of material, and all rhizomes were potted in peat moss

which was kept thoroughly saturated with water at all times. Constant temperatures were provided with a Central Scientific Low-Temperature Incubator. All measurements of increase in length were made in terms of millimeters, and tips used for actual nuclear counts were prepared using the Feulgen technique together with a squash method. Counts were made using a 10x ocular and a 43x objective. Obeservations of the effects of various temperatures upon the mitotic figures were made using a 97x objective. The number of dividing nuclei was determined by actually counting the number of nuclei undergoing some stage of mitosis within a root

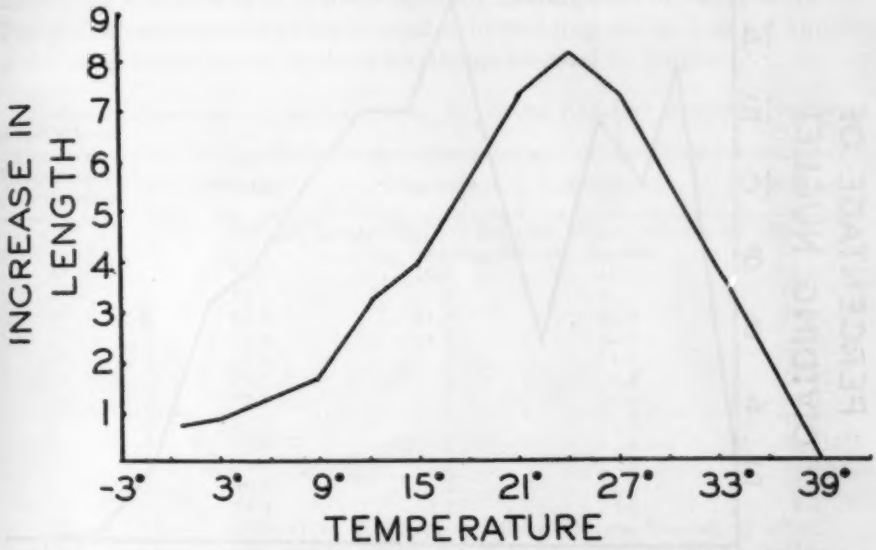

FIG. 1. Curve showing increase in length of root tips of *T. sessile* L. at various temperatures between −3° C. and 39° C. Temperature intervals are shown along the horizontal axis; millimeters increase in length over a 96 hour period are shown along the vertical axis.

tip 1 mm. in length, and the percentages of dividing nuclei were determined from this count after estimating the number of nuclei within the root tips.

Observations and discussion. Young root tips of *Trillium sessile* L. were exposed to various temperatures ranging from −3° C. to 39° C. for periods of 96 hours. Temperature intervals of 3° C. were used and these temperatures may be seen along the horizontal axis in figure 1. Increase in length of the roots was determined by measuring the entire length of roots before and after exposure to the various temperatures for 96 hours. Increase in length at the various temperatures is represented along the vertical axis in figure 1. The average length of roots used to determine increase in length was approximately 12 mm. before exposure.

By observing the growth curve in figure 1 it can be seen that maximum increase in length takes place at 24° C. At this temperature increase in length over a 96 hour period was 8.2 mm. At temperatures above 24° C. there is a gradual decrease in the rate of growth until at 39° C. no increase in length was apparent. At 39° C. the tips appear to be very soft. At 1° C. tips show an increase in length of .7 mm. over the 96 hour period. Above 1° C. there is a gradual increase in length until the maximum is reached at 24° C. Actually there is a very slight increase in length at −3° C. but this increase is probably that which could be expected to take place before

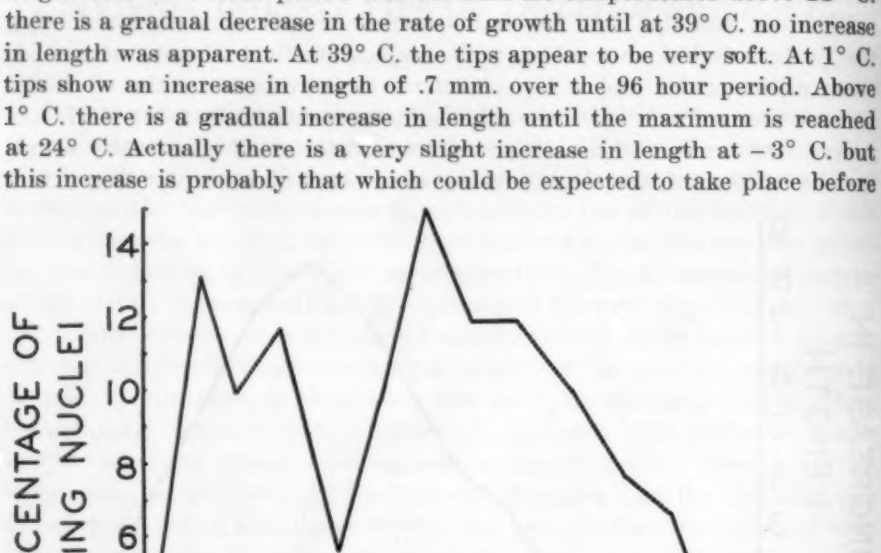

FIG. 2. Curve showing percentage of dividing nuclei at various temperatures between −3° C. and 39° C. Temperature intervals are given along the horizontal axis; percentages of dividing nuclei are given along the vertical axis.

the temperature of −3° C. is reached. As will be shown later, increase in length could not be expected to take place at −3° C. because of the effects upon the mitotic figure; this is also true at 39° C.

Figure 2 shows the percentage of dividing nuclei in root tips exposed to various temperatures for 96 hours. Temperature intervals are given along the horizontal axis whereas the percentages of dividing nuclei are given along the vertical axis.

From the curve in figure 2 it can be observed that the maximum number of dividing nuclei is to be found at 15° C. At this temperature 14.8% of

the nuclei are in some stage of mitosis. At temperatures above 15° C. there is a gradual decrease in the percentage of dividing nuclei until at 36° C. only .13% of the total number of nuclei are dividing and at 39° C. no nuclei are observed in any stage of mitosis.

At this point a comparison between the growth curve in figure 1 and the curve in figure 2 may be made. Maximum increase in length was observed at 24° C. whereas the maximum number of dividing nuclei is found at a temperature of 15° C. At 15° C. increase in length is 3.7 mm. over the 96 hour period as compared with 8.2 mm. at 24° C. At 24° C. 9.8% of the nuclei were observed to be actively dividing as compared to 14.8% at 15° C. This indicates that the maximum number of dividing nuclei does not appear at the same temperature as does maximum increase in length.

TABLE 1. *Percentage of dividing nuclei in various stages of mitosis at indicated temperatures.*

Temperature (Centigrade)	Prophase	Metaphase	Anaphase	Telophase
−3°	Difficult to differentiate between stages because of effects upon mitotic figures.			
1°	63.9	19.7	12.5	3.9
3°	58.7	3.4	15.4	22.4
6°	65.3	11.3	11.9	11.4
9°	76.8	1.4	12.6	9.2
12°	74.4	.4	11.1	14.1
15°	78.4	.1	8.4	12.6
18°	75.9	.1	12.7	12.0
21°	73.8	.1	11.3	14.8
24°	77.6	.1	11.6	10.7
27°	74.9	.3	11.2	13.5
30°	70.0	.2	18.1	12.0
33°	78.6	1.2	11.9	8.2
36°	Difficult to differentiate between stages because of effect upon mitotic figures. No nuclei were observed to be dividing.			
39°				

At temperatures below 15° C. there is a gradual decrease in the percentage of dividing nuclei until at 9° C. 5.4% of the nuclei may be observed in some stage of mitosis (fig. 2). At temperatures of 6° C., 3° C., and 1° C., however, there is an increase in the percentage of dividing nuclei over that for 9°C. At 6° C. 11.5% of the nuclei are dividing, at 3° C. 9.8%, and at 1° C. 13.0% of the nuclei are dividing (fig. 2). At 3° C. one and a half times as many nuclei are dividing as at 24° C., however, at 3° C. increase in length is only .8 mm. as compared with 8.2 mm. at 24° C. A similar comparison can be made for temperatures of 1° C. and 6° C. These comparisons of percentages of dividing nuclei and increase in length at lower temperatures further indicates that the correlation between increase in length and the percentage of dividing nuclei is not a close correlation. At −3° C. 2.6% of the nuclei could possibly be observed as being in some stage of mitosis, however, the mitotic figures appeared to be very abnormal.

Perhaps an explanation of the fact that a greater percentage of dividing nuclei are to be observed at lower temperatures where very little increase in length is apparent can be found when the percentage of dividing nuclei is broken down into the various stages of mitosis. In Table 1 the percentage of dividing nuclei observed to be in some phase of the conventional prophase, metaphase, anaphase, or telophase can be observed in the columns headed as such. Between 9° C. and 33° C. the average percentage of dividing nuclei in prophase is approximately 75.6%, the range being from 70.0% at 30° C. to 78.6% at 33° C. Metaphases show an average of approximately .4%, anaphases approximately 12.1%, and telophases approximately 11.9%. At 1° C. the percentage of prophases is low compared to the above average, being 63.9%. The percentage of metaphases is abnormally high with an approximate average of 19.7%. The percentage of anaphases compares favorably, but the percentage of telophases is only 3.9%. These figures indicate that the process of mitosis has been slowed down at the metaphase. The nuclei possibly enter and complete the prophase of mitosis but a temperature of 1° C. is sufficient in some way to inhibit the action of the spindle mechanism. This inhibition of the spindle mechanism may be apparent throughout anaphase accounting for the abnormally low percentage of telophases. At 6° C. the same "slowing down" process seems to be operating at metaphase. At 6° C. the percentage of prophases is 65.3%, whereas the percentage of metaphases is 11.3%. The percentage of anaphases and telophases are about the same as for temperatures between 9° C. and 33° C., 11.9% and 11.4% respectively. A temperature of 3° C. shows a slightly different pattern. At 3° C. prophases show a percentage of 58.7% and metaphases a percentage of 3.4%. This percentage of metaphases is lower than at 1° C. and 6° C. Anaphases show a percentage of 15.4% and the percentage of telophases is 22.4%. This indicates that the inhibition or "slowing down" mechanism operates in the later stages of mitosis at 3° C. but somewhat earlier during the process at temperatures of 1° C. and 6° C. No such "slowing down" of the mitotic process is evident at higher temperatures, but at these higher temperatures there does seem to be a slowing down in the number of nuclei that enter prophase.

Measurements were made of cell size in order to determine whether increase in length of the root tips was due to an actual speeding-up of mitosis or to an increase in cell size following cell division. These measurements of cell size were made on root tips which had been exposed to temperatures of 3° C. and 24° C. for 96 hours, sectioned and stained with iron alum hematoxylin. Measurements were made with an ocular micrometer on approximately 1000 cells for each temperature exposure. Temperatures of 3° C. and 24° C. were selected because at these temperatures the same percentage of nuclei are apparently dividing, that is 9.8%,

whereas increase in length is approximately 10 times greater at 24° C. Increase in length at 24° C. was 8.2 mm., but at 3° C. increase in length was only .8 mm. (fig. 1). The average length of cells in root tips which had been exposed to 3° C. for 96 hours was 24.7 microns, whereas at 24° C. the average length was 19.4 microns. This indicates that the greater increase in length of the root tips at 24° C. was not due to a greater increase in cell size following cell division. This lends further support to the idea that the greater percentage of mitotic figures found at lower temperatures is due to a "piling-up" effect of the mitotic figures rather than a speeding-up of the process of mitosis.

A study of the mitotic figures themselves indicates something of the degree to which the root tips have been damaged by these extreme temperatures. At temperatures between 9° C. and 33° C. all mitotic figures appeared to be perfectly normal. After exposure to 36° C. for 96 hours the mitotic figures appeared to be somewhat abnormal in the later stages of mitosis, however, the early prophases appeared to be normal. Fewer dividing nuclei were observed at 36° C. than at 33° C. (fig. 2). The nuclei that were not actively dividing also appeared to be normal, however, the rhizomes became very soft and disintegrated after exposure to 36° C. for 96 hours indicating that *Trillium sessile L.* could not survive this temperature. After exposure to 39° C. for 96 hours there were formed within the nuclei a number of dark staining, spherical bodies. These bodies within the nucleus were variable as to size and the number formed was also variable, the number varying from 5 to 40 or more. Such bodies probably represent the protein portion of the nucleus which has coagulated at this high temperature.

At temperatures of 1° C., 3° C., and 6° C. the mitotic figures were apparently normal except for the fact that the chromosomes appeared to show greater than normal mitotic contraction and also the differential segments that have been observed by Darlington and LaCour (1938, 1940), Wilson and Boothroyd (1941, 1944), and Bailey (1949, 1952). There were probably fewer differential segments at 6° C., however, than at 3° C. and 1° C. The terminal segments were more evident at 6° C. than were the intermediate segment.

After exposure to – 3° C. for 96 hours both the dividing and interphase nuclei appeared to be very abnormal. Those nuclei not undergoing mitosis appeared to be very vacuolate and were somewhat abnormal in shape, that is, they were not spherical. Some of these nuclei approached being rectangular in shape. The chromosomes themselves had lost their distinctness to the point that it was very difficult to distinguish between the various stages of mitosis. In a great many instances the chromosomes had clumped together to the point that it was almost impossible to recognize them as such. In other instances the chromosomes had become very long, but in no in-

stance could individual chromosomes be recognized, that is, chromosomes A, B, C, D, and E.

An attempt was made to determine to what extent the root tips would recover after having been exposed to temperatures of – 3° C., 1° C., 3° C., 6° C., 36° C., and 39° C. These are the temperatures at which the percentages of dividing nuclei varied from the normal and in some instances temperatures where the mitotic figures appeared to be abnormal. In order to determine recovery, root tips were exposed to the various temperatures for 96 hours, and at the end of this period the tips were then transferred to a temperature of 21° C for 24 hours. The rhizomes were left in the same peat moss, undisturbed for both exposures. At the end of the recovery period, that is, 21° C. for 24 hours, the root tips were removed, prepared in the usual manner, and the percentage of dividing nuclei determined. After exposure to 39° C. for 96 hours and recovery at 21° C. for 24 hours no dividing nuclei were observed in any of the root tips. After 36° C. for 96 hours and recovery for 24 hours at 21° C. .65% of the nuclei were observed to be in some stage of mitosis. Some root tips were allowed to recover for 48 hours after having been exposed to 36° C. for 96 hours and no nuclei were seen to be dividing at the end of this period. These studies on recovery indicate that root tips of *Trillium sessile* L. fail to survive temperatures of 36° C. and 39° C for periods of 96 hours.

After exposure to 6° C. for 96 hours and recovery for 24 hours at 21° 6.7% of the nuclei were dividing; after 3° C. and recovery for 24 hours at 21° C. 11.4% of the nuclei were in some stage of mitosis. 11.3% of the nuclei were observed to be in some stage of mitosis after having been exposed to 1° C. for 96 hours and then allowed to recover for 24 hours at 21° C. There was no apparent recovery after exposure to – 3° C. for 96 hours. After recovery at 21° C. for 24 hours the mitotic figures had the same appearance as before recovery, that is the chromosomes had lost their distinctness, etc. The so-called resting nuclei continued to have the very vacuolate appearance as well as retain the abnormal shapes. These results would certainly indicate that root tips fail to survive a temperature of – 3° C. for a period of 96 hours.

Root tips of *Trillium sessile* L. were also exposed to a temperature of 36° C. for varying periods of time and the percentage of dividing nuclei determined after each exposure. After 24° C. for 24 hours 3.7% of the nuclei were dividing, after 48 hours exposure 4.8%, after 72 hours 1.6%, after 96 hours 1.9% and after exposure to 36° C. for 120 hours no nuclei were observed to be dividing. These percentages indicate that temperature effects are somewhat gradual. The fact that a greater percentage of nuclei are seen to be dividing after 48 hours exposure than after 24 hours exposure may indicate that there is a temporary "shock" to the cells when they are suddenly placed in abnormal temperatures.

Summary

1. Maximum increase in length of the root tips of *Trillium sessile* L. does not take place at the same temperature where the greatest percentage of dividing nuclei are to be observed. Maximum increase in length of root tips takes place at 24° C. whereas the maximum number of dividing nuclei is to be observed at a temperature of 15° C. At temperatures of 1° C., 3° C., and 6° C. a high percentage of nuclei are seen to be dividing, but at these temperatures very little increase in length takes place.

2. There seems to be a "slowing down" of the spindle mechanism at lower temperatures which probably accounts for the high percentage of dividing nuclei at these low temperatures with little increase in length of the root tips.

3. Mitotic figures appear to be normal after exposure to temperatures between 1° C. and 33° C. for 96 hours. Mitotic figures appear to be very abnormal at – 3° C., and these nuclei not actively dividing also appear to be abnormal at temperatures of – 3° C. and 39° C. after exposure for 96 hours.

4. Studies on recovery indicate that *Trillium sessile* L. fails to survive temperatures of – 3° C., 36° C., and 39° C. for a period of 96 hours.

5. Temperature effects upon the dividing nucleus are somewhat gradual.

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SOME TROPICAL AMERICAN STIPITATE STEREUMS

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During the summer of 1952, many specimens of stipitate Stereums and other fungi were collected in Panamá and Costa Rica by Professor G. W. Martin and myself. The main portion of the collecting was limited to the Canal Zone Biological Area, Gatun Lake, Canal Zone. Other collecting areas were several other localities in the Canal Zone, on the slopes of El Volcán above Boquete at an elevation of about 7000 ft., at Puerto Armuelles in the Chiriquí coastal region and at Palmar Norte, Puntarenas Province, Costa Rica. The stipitate Stereums are not only an interesting group within themselves, but form a very noticeable portion of the mycobiota of the region, and for this reason attracted our attention.

Upon return to the United States, attempts were made to assign names to the collections, but these attempts were not always successful. The method of hyphal analysis first used by Corner in his studies on polypores and Clavarioid fungi (1950, 1953) has been applied successfully by others in this laboratory in investigations of other Homobasidiomycetes. An attempt was made to apply this method in delimiting species in this group of Basidiomycetes also. It has, in my opinion, been successful.

The stipitate Stereums are predominately a warm temperate and tropical group of fungi, although some species are found in the northern United States, *i.e., S. diaphanum*. Earlier mycologists, including Fries, Léveille, Berkeley and Curtis, based their species entirely on the external, macroscopic characters. The compilation of the species was done by Massee (1890) who added little to the original descriptions. While Lloyd (1913) gives excellent photographs of practically all of the species and some notes on synonymy, he, also, utilized only external characters. Burt (1920) was probably the first mycologist to rework the group extensively, using microscopic as well as macroscopic characters. Although Burt emphasized the central-stemmed and lateral-stemmed character, which is not as constant as he suggests, he did bring a higher degree of stability to the group. He probably realized this variation in central- and lateral-stemmed species, for he attempted to account for such variation in his keys. Martin (1939, 1944), describing specimens collected in Panamá and Colombia, added notes about distribution and variation within the group, and added measurements to species already described.

An analysis of the component parts of the basidiocarp is not the easiest method of identification, but it is believed that the microscopic features

present a more constant picture than macroscopic ones. Since correct identification of a species depends on a good section and a spore print, a word about the methods used and structures named may not be out of place.

It cannot be overemphasized that a good spore print is necessary to insure a quantity of mature spores and greater accuracy in spore measurements. The spore print should be made, if possible, within the first 24 hours after collection of the specimens. In observing the structure of the basidiocarp, a very thin section of the pileus and stipe cut in elder pith with a razor is almost essential. In addition, portions of the hymenium smashed on a slide sometimes provide an excellent means for checking measurements. Sections mounted in 3% KOH and stained with Phloxine were used throughout this study, but for comparison slides were mounted in Cotton Blue dissolved in lactophenol. Lactophenol evaporates more slowly than KOH and permits the slide to be kept over a longer period of time. In many tropical Basidiomycetes the hymenium is packed with basidioles, cystidioles and other structures. A light tapping on the cover slip is useful in separating the component parts so they may be more readily observed.

The term "pileocystidium" refers to a definite, thick-walled hyphal structure differing somewhat from the contextual hyphae. It is sometimes septate. Pileocystidia are borne projecting upwards from the superior surface of the pileus. In most species with pileocystidia, these are readily seen, but care must be exercised to be sure that the fungus, and not the section, lacks them. "Caulocystidium" refers to a hyphal structure similar to a pileocystidium which occurs on the stipes of certain species. Sometimes caulocystidia are obscured by outward growing hyphae, but a tapping of the cover slip will usually reveal them. The term "gloeocystidium" refers to the rather long, sometimes tortuous, ventricose to cylindrical structures which arise in the subhymenium and extend into, but rarely beyond, the hymenium. They usually stain more heavily with Phloxine than adjacent structures. In addition to ventricose or cylindrical gloeocystidia, *S. Ravenelii* has short-cylindrical and short-globose gloeocystidia. These structures are recognizable as gloeocystidia by their origin in the subhymenium and their staining properties. Due to crowding in the hymenium gloeocystidia are occasionally obscure. "Cystidia" are structures which arise in the hymenium and may or may not project beyond it. They are long and cylindrical and project beyond the hymenium in the species discussed here.

Basidia are usually rather difficult to see. They are, in all species in which they were observed, cylindrical-clavate with 2-4-sterigmata, which may be either long or short. The exact number of sterigmata seems to be a specific difference. The measurements of basidial length are more or less

approximate since in many cases the actual point of origin was difficult to determine. For this reason and the difficulty of observing them in a packed hymenium, basidial length is not stressed. The length of basidia, at least in *S. elegans,* seems to be a function of hymenial thickness, but no definite conclusions can be made at this time. In this group of fungi there are three types of hyphae: skeletal, generative and binding hyphae. Using Corner's terms (for a discussion of these terms and of the various hyphal types see Corner, 1953), there are five monomitic, four dimitic with skeletal hyphae and one trimitic species discussed here.

In addition to specimens collected during the summer of 1952, collections deposited in the State University of Iowa Herbarium by Martin and others, specimens of some of the species deposited in the New York Botanical Garden and specimens from the Berkeley Herbarium on deposit at the Royal Botanic Gardens, Kew, were compared in so far as time permitted.

KEY TO SPECIES

1—Hyphal system monomitic; clamp-connections present or absent; gloeocystidia present or absent. (2)
2—Spores longer than broad; hymenium yellow or yellowish when dry; clamp-connections absent. (3)
2—Spores globose; hymenium Deep Quaker Drab or turning dark purple-brown when bruised or with age; clamp-connections present. (5)
3—Fructifications usually under 10 cm. in total length; cystidia absent. *S. cyphelloides*
3—Fructifications usually over 10 cm. in total length; cystidia present, long-cylindrical, emergent from the hymenium. (4)
4—Fructifications spathulate or flabelliform, usually on wood, occasionally on soil. *S. aurantiacum*
4—Fructifications more or less infundibuliform; on soil. *S. diaphanum*
5—Fructifications small, usually under 30 cm. in total length; hymenium Dark Quaker Drab when dry; basidia 3-4-sterigmate; spores usually 4.8 μ in diam., apiculate; on soil. *S. pusiolum*
5—Fructifications large, usually over 30 cm. in length; hymenium turning dark purple-brown when bruised or with age; chalk-white when fresh; basidia 2-3(-4)-sterigmate; spores usually 6.4 μ in diam., apiculate; on wood. *S. radicans*
1—Hyphal system dimitic or trimitic; clamp-connections always present; gleocystidia present or absent. (6)
6—Fructifications very large, infundibuliform, dark velvety brown, with large prominent spines at the base of the pileus; thick-walled brown hyphae projecting from hymenial surface, often incrusted; hyphal system trimitic; superior surface of pileus covered with long, projecting brownish-yellow hyphae. *S. hydrophorum*

6—Fructifications large or small, but not as large as preceding; lacking prominent spines at the base of the pileus; pileus variable in shape and lacking long, projecting, brownish-yellow hyphae on the superior surface; gloeocystidia present. (7)

7—Upper layer of pileus spongy because of loose wefts of hyphae, some of which are organized into columns which anastomose, forming air spaces that are more or less filled with hyphae. (*Cladoderris dendritica*)

7—Upper surface of pileus closely compacted and not having a spongy appearance. (8)

8—Spores $3.2 \times 2.4\ \mu$; fructifications usually infundibuliform, arising from a prominent, well-developed, pulvinate mycelial pad; caulocystidia present, sometimes organized into a palisade layer, projecting from the stipe surface up to $30\ \mu$. *S. surinamense*

8—Spores $4.8 \times 3.2\ \mu$; fructifications variable in shape; mycelial pad present or absent, usually not as well-developed as in preceding; caulocystidia present or absent, if present, projecting from stipe surface more than $30\ \mu$. (9)

9—Pileocystidia and caulocystidia absent; gloeocystidia usually long, flexuous, sometimes projecting above the hymenium, then curved back into it. *S. Ravenelii*

9—Both pileocystidia and caulocystidia present; gloecystidia usually ventricose to subcylindrical, rarely, if ever projecting above the hymenium and curved back into it. (10)

10—Fructifications usually separate, distinct, with a large number of projecting pileocystidia at the base of the pileus and over the stipe (caulocystidia) which are noticeable under hand lens. *S. pergamenum*

10—Fructifications usually densely caespitose but with distinct stipes; without noticeable hairs at the base of the pileus or over the stipe; hymenium sometimes replaced by chlamydospores. *S. elegans*

STEREUM CYPHELLOIDES Berk. & Curt. Jour. Linn. Soc. Bot. *10:* 331. 1868.

Fructifications stipitate, sometimes almost sessile, gregarious to crowded, bibulous, pileus flabelliform to spathulate, longitudinally fibrillose, drying pale Yellow-Orange (R), 5–8 × 3–6 mm., margin entire, no pileocystidia; stipe short, rugulose, concolorous, sometimes flattened, 1–2 × 0.5–1 mm.

Pileus in section up to 500 μ thick; hyphal structure monomitic, hyphae without clamp-connections, 2–5 μ in diam.; basidia cylindrical-clavate, 22–28 × 4–5 μ, with four sterigmata, each 3.2–4.8 μ long; cystidia and gloeocystidia absent; spores hyaline, even, non-guttulate, or rarely so; 4.8 × 3.2–4 μ; on soil.

SPECIMENS EXAMINED: *Jamaica:* W. Harris 19–2–1908 (NYBG). F. S. Earle Oct. 20–Nov. 24, 1902 (NYBG); *Cuba:* C. A. Wright *511* (TYPE) in Herb. Berk. 1879 (Kew); *Colombia:* Sierra Nevada de Santa Marta, Dept. Magdalena GWM *3203, 3229, 3402, 3526,* (SUI).

Lloyd (1913), Burt (1920) and Martin (1944) note that this species is white when fresh and becomes some shade of yellow or buff upon drying. Burt describes the hymenium as sometimes continuing down the inferior side of the stipe and the stipe, therefore, is only a narrowed portion of the pileus. Martin's spore measurements are larger than those reported by either Burt or myself, but these differences are only slight.

STEREUM AURANTIACUM (Pers. ex Fr.) Lloyd, Myc. Writ. 4, Stipitate Stereum 22. 1913.

Fructifications stipitate, membranous, soft, drying Naples Yellow (R), gregarious, crowded or sometimes separate; pileus wedge-shaped, spathulate or flabelliform, upper surface lineate-striate, sometimes more or less tomentose because of loose hyphae on surface of pileus, no pileocystidia, margin fimbriate, 4–40 × 5–50 mm.; stipe cylindrical, thin, with yellowish or whitish tomentum at base, concolorous with pileus, occasionally lighter toward base, no caulocystidia, 4–10 × 0.5–2 mm.

Pileus in section 300 μ thick; hyphal structure monomitic, hyphae without clamp-connections, some with slightly thickened walls, arranged longitudinally parallel in the context, 3–5(–7) μ in diam.; basidia cylindrical-clavate, 30–37 × 4.8–6.4 μ, with four sterigmata, each 3.2–4.8 μ long; cystidial long-cylindrical, occasionally with swollen tips, non- to 3-septate, emergent from the hymenium up to 70 μ, 6–14 μ in diam., young cystidia embedded in the hymenium, clavate to cylindrical; spores even, hyaline, non- to several-guttulate, 6–8(–9.6) × 3–5 μ; on wood or soil.

SPECIMENS EXAMINED: *Bahamas:* L. J. K. Bruce *1772* (NYBG); *Jamaica:* Port Antonio, A. E. Wright, *1909,* F. S. Earle *260,* pure white when collected, F. S. Earle *600* (NYBG); *Santo Domingo:* Consuelo, N. Taylor *176* (NYBG); *Puerto Rico:* Bruce Fink *882,* Rio Piedras, J. R. Johnston *483,* on soil, Martin Pence, J. R. Johnston *1086,* on soil, Rio Piedras, J. A. Stevenson *5585,* white when collected, (NYBG); *Cuba:* base of Yunque Mts., Underwood & Earle *861,* Bros. Leon & Clement *5570* (NYBG);

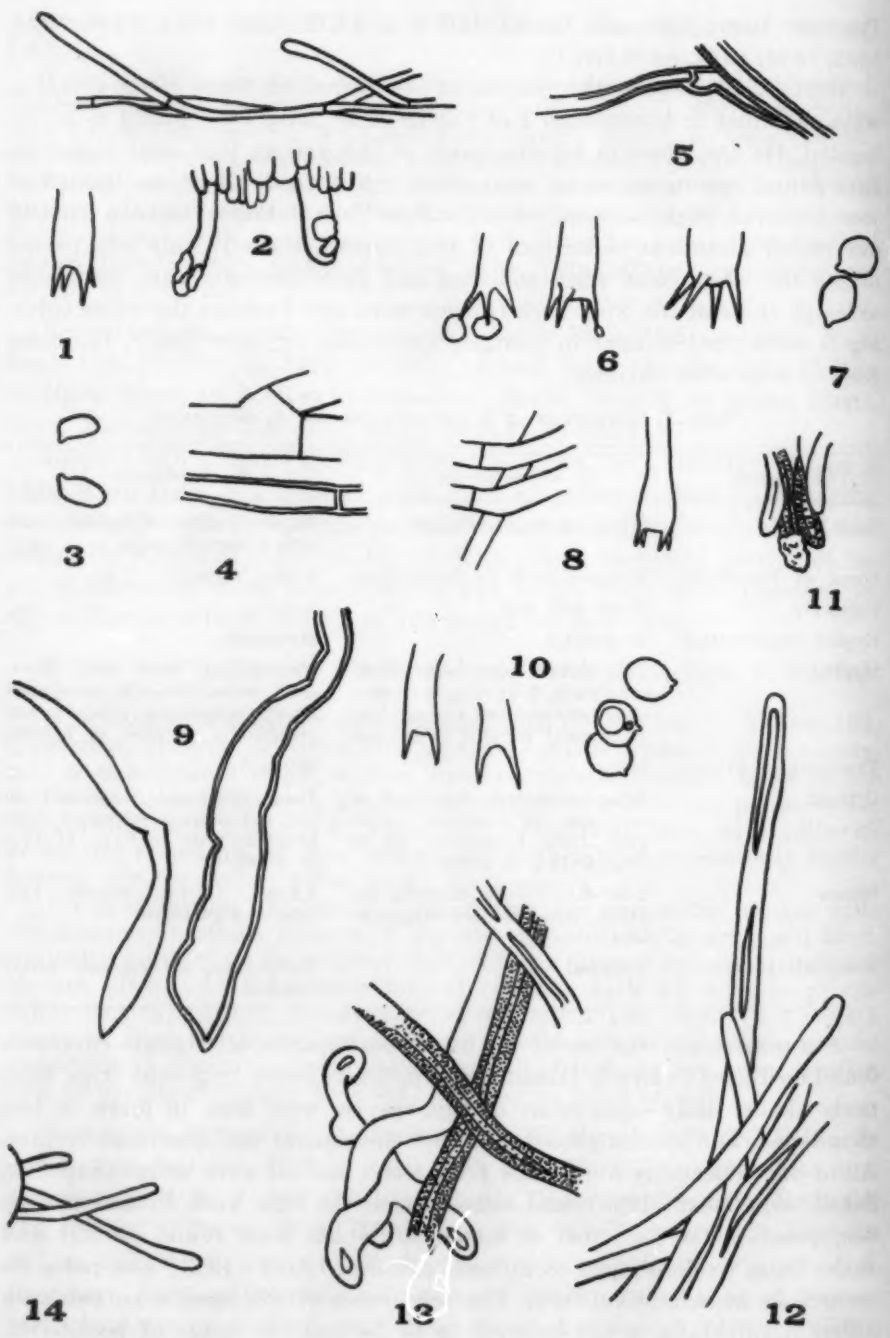
Panamá: Barro Colorado Island, GWM & ALW *7168, 7201, 7346, 7338, 7393, 7634, 8444, 8529* (SUI).

Burt (1920) reports the cystidia as non-incrusted. Some of the cystidia, when mounted in lactophenol and Cotton Blue, have been found to be incrusted. He also notes in his discussion of this species that some collectors have found specimens which were white when fresh. Notes to this effect were found on packets deposited at the New York Botanical Garden. Among our rather abundant collections of this species, there is only one packet noting the white color when collected and these specimens are immature, although those at the New York Garden were not. Perhaps the white coloring is more predominant in younger specimens, or, more likely, the color itself is somewhat variable.

TABLE 1. *Comparison of S. aurantiacum and S. diaphanum*

Characters	*S. aurantiacum*	*S. diaphanum*
Color	White to Naples Yellow	Naples Yellow or lighter, some with brownish tints
Shape of fruit-body	Wedge-shaped to flabelliform	Flabelliform
Substrate	Wood and soil	Soil
Hyphal construction	Monomitic	Monomitic
Hyphae	Thin-walled, some with thickened walls, 3–5(–7) μ in diam.; clamp-connections absent; longitudinally parallel in context	Thin-walled, some with thickened walls, 3–6.4 μ in diam.; clamp-connections absent; longitudinally parallel in context
Thickness of pileus	300 μ	300–375 μ
Cystidia	Long-cylindrical, incrusted or not, non- to 3-septate, emergent from hymenium up to 70 μ, 6–14 μ in diam.	Long-cylindrical, incrusted or not, not septate, emergent from hymenium up to 51 μ, 11–14 μ in diam.
Spores	6–8(–9.6) × 3–5 μ, smooth, hyaline, non- to several-guttulate	4.8–6.4 × 3.2–4 μ, smooth hyaline, non-guttulate
Distribution	Tropical	Temperate, subtropical, rarely tropical

S. aurantiacum was one of the commonest species of stipitate Stereums found on Barro Colorado Island. On practically every trip—the trips were made almost daily—specimens of this species were seen in more or less abundance. The species probably occurs throughout the American tropics. All of our collections were made from wood and all were wedge-shaped to flabelliform. Burt (1920), and collections at the New York Botanical Garden, point to the fact that *S. aurantiacum* has been found on soil and varies from wedge-shaped to infundibuliform. Lloyd (1913) also notes its occurrence as infundibuliform. The occurrence of this species on two such different substrates is not believed to be beyond the range of possibility.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The variety of shapes of the fruit-body is believed to be the result of confusing two, as yet, distinct species. Upon comparing the descriptions of *S. aurantiacum* and *S. diaphanum*, it will be noted that the only significant differences between the two species is the shape of the fruit-body, the different substrates and the spore sizes. If the significant characteristics of the two are tabulated (see table I), the similarities are more apparent.

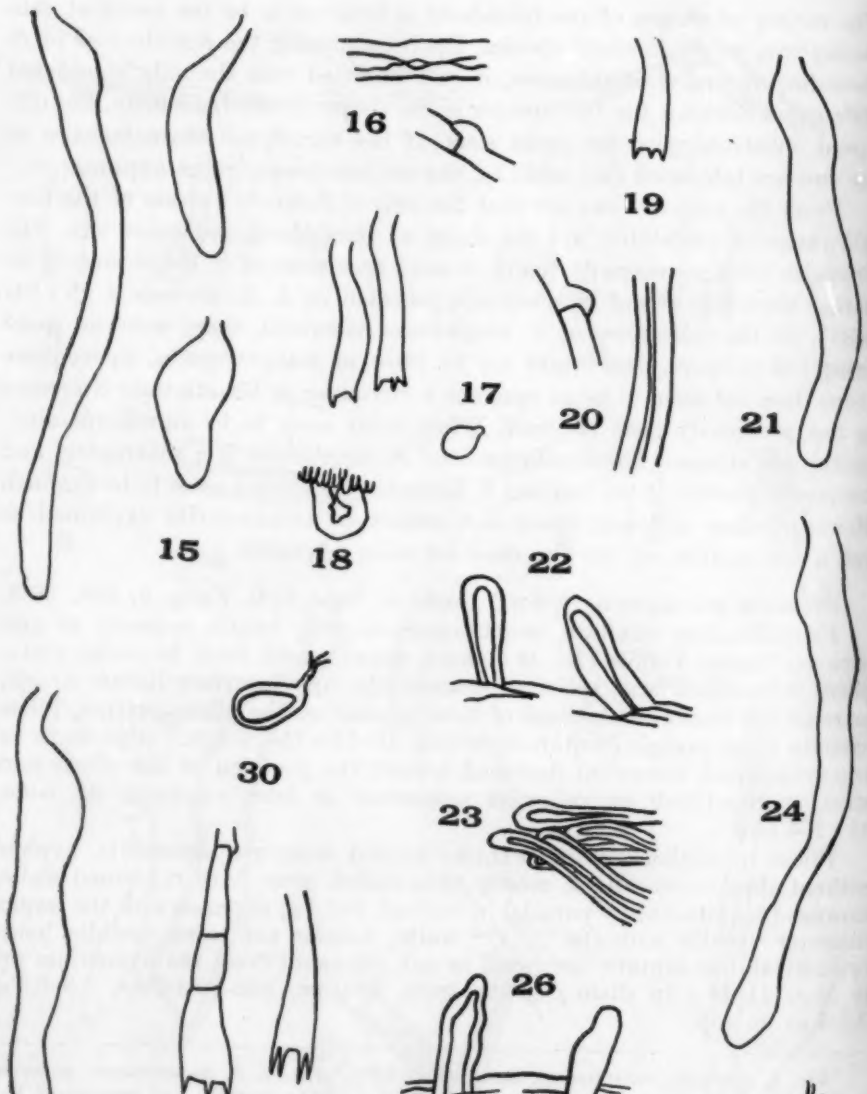
From the table we can see that the only differences outside of the normal range of variability are the shape of sporophore and spore size. The brownish color occasionally found in some specimens of *S. diaphanum* is no darker than that found in specimens collected by J. A. Stevenson (NYBG *5585*). In the collections of *S. diaphanum* examined, there were no spore prints; thus spore sizes might not be those of mature spores. Sporophore shape does not seem to be as constant a character in the stipitate Stereums as has previously been believed. When what seem to be significant similarities are stressed, the conclusion that *S. diaphanum* is a subtropical and temperate variety of the tropical *S. aurantiacum* cannot seem to be avoided. However, since different spore size cannot be satisfactorily explained as yet, a combination of the two does not seem advisable.

STEREUM DIAPHANUM (Schw.) Cooke in Sacc. Syll. Fung. *6:* 558. 1888.

Fructifications stipitate, membranous, slightly brittle, separate or gregarious, Naples Yellow (R) or lighter, usually with faint brownish tints; pileus infundibuliform, splitting occasionally, upper surface lineate-striate, more or less tomentose because of loose hyphae on the pileus surface, pileocystidia none, margin dentate-fimbriate, 10–15 × 15–20 mm.; stipe more or less cylindrical, somewhat flattened toward the junction of the pileus and stipe, with whitish or yellowish tomentum at base, caulocystidia none, 15 × 1–4 mm.

Pileus in section 300–375 μ thick; hyphal structure monomitic, hyphae without clamp-connections, mostly thin-walled, some with thickened walls, arranged longitudinally parallel in context, 3–6.4 μ, the ones with the larger diameter usually with the thicker walls; *basidia not seen;* cystidia long-cylindrical, non-septate, incrusted or not, emergent from the hymenium up to 51 μ, 11–14 μ in diam.; spores even, hyaline, non-guttulate, 4.8–6.4 × 3.2–4 μ; on soil.

FIG. 1. *Stereum aurantiacum*, basidium, × 1000. FIG. 2. *S. aurantiacum*, superior surface of pileus showing projecting hyphal hairs, × 467; cystidia and portion of hymenium, × 467. FIG. 3. *S. aurantiacum*, basidiospores, × 1000. FIG. 4. *S. aurantiacum*, hyphae, × 1000. FIG. 5. *S. pusiolum*, hyphae, × 1000. FIG. 6. *S. pusiolum*, basidia, × 1000. FIG. 7. *S. pusiolum*, basidiospores, × 1000. FIG. 8. *S. cyphelloides*, hyphae and basidia, × 1000. FIG. 9. *S. radicans*, gloeocystidia, × 1000. FIG. 10. *S. radicans*, basidia and basidiospores, × 1000. FIG. 11. *S. hydrophorum*, portion of hymenium showing emergent, occasionally incrusted, thick-walled, brown hyphae. FIG. 12. *S. hydrophorum*, hyphal hairs projecting from superior surface of pileus, × 467. FIG. 13. *S. hydrophorum*, thick-walled skeletal hyphae, both colorless and brown, and binding hyphae, × 1000. FIG. 14. *S. hydrophorum*, caulocystidia, × 240.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SPECIMENS EXAMINED: *Jamaica:* W. A. Murrill & W. Harris *1112* (NYBG); *Missouri:* Atchison, B. Shimek (SUI); *Iowa:* Delaware Co., B. Shimek, White Pine Hollow State Park, M. J. Fay (SUI); *China:* Nanking, S. C. Teng (SUI).

For a discussion of the relationships of this species see the previous species description.

Burt gives a wider range for this species, from New York to Alabama, Ohio, Missouri, Washington and California. The hyphal hairs which project from the upper surface of the pileus of this species and *S. aurantiacum* are not considered pileocystidia because they do not differ from contextual hyphae. It is believed best to refer to them as projecting hyphal hairs, reserving the term "pileocystidia" for those structures which are thick-walled and differ from contextual hyphae.

S. cyphelloides, S. aurantiacum and *S. diaphanum,* when considered in relation to other stipitate Stereums, exhibit several striking differences. All three species are monomitic and lack clamp-connections and gloeocystidia. All other stipitate Stereums differ either in possessing gloeocystidia or a different hyphal system or both and all others have clamp-connections. These three species obviously form a homogenous element to which other species may be added in the future. The only other monomitic species studied are *S. pusiolum* and *S. radicans* but these species have clamp-connections and gloeocystidia.

STEREUM PUSIOLUM Berk. & Curt., Jour. Linn. Soc. Bot. *10:* 330. 1868.

Fructifications stipitate, fleshy-coriaceous, curling in drying, gregarious or crowded; pileus spathulate to flabelliform, or thelephoroid, and more or less split into lobes, more or less longitudinally furrowed, drying ochraceous or slightly darker, underside even, drying Deep Quaker Drab (R), contracting and splitting sometimes in drying, pileocystidia none, margin lobed-dentate; stem short, larger toward base, concolorous with upper surface of pileus or somewhat lighter, caulocystidia absent; entire fructification about 3×15 mm.

Pileus in section 395–400 μ thick; hyphal structure monomitic, hyphae with clamp-connections, some with thickened walls, 1.6–3.2 μ in diam.; basidia cylindrical-clavate, $27–32 \times 4.8–6.2$ μ, with three to four sterigmata, each 4–6.4 μ long; gloeocystidia more or less cylindrical-clavate, some with

FIG. 15. *Stereum Ravenelii,* gloeocystidia, the two on the right from the type collection, $\times 1000$. FIG. 16. *S. Ravenelii,* skeletal and generative hyphae, $\times 1000$. FIG. 17. *S. Ravenelii,* basidia and basidiospores, $\times 1000$. FIG. 18. *S. Ravenelii,* portion of hymenium showing incurving gloeocystidia, $\times 467$. FIG. 19. *S. surinamense,* basidium, $\times 1000$. FIG. 20. *S. surinamense,* skeletal and generative hyphae, $\times 1000$. FIG. 21. *S. surinamense,* gloeocystidium, $\times 1000$. FIG. 22. *S. pergamenum,* pileocystidia, $\times 467$. FIG. 23. *S. pergamenum,* caulocystidia, $\times 240$. FIG. 24. *S. pergamenum,* gloeocystidium, $\times 1000$. FIG. 25. *S. elegans,* caulocystidia, $\times 240$. FIG. 26. *S. elegans,* pileocystidia, $\times 467$. FIG. 27. *S. elegans,* skeletal and generative hyphae, $\times 1000$. FIG. 28. *S. elegans,* basidia and basidiospores, $\times 1000$. FIG. 29. *S. elegans,* gloeocystidium, $\times 1000$. FIG. 30. *S. elegans,* chlamydospore, $\times 1000$.

attenuated tips, often filled with brownish-yellow refractile material, usually between 40–60 × 6–8 μ; amorphous brownish-yellow, refractile material present in hymenium; more or less subglobose or globose bodies also present in hymenium and seem to arise by pinching off of hyphal tips; spores subglobose, pip-shaped, even, hyaline, 4.8 μ in diam.; on soil.

Specimens examined: *Puerto Rico:* Rio Piedras, J. R. Johnston *89* (NYBG); *Cuba:* Base of El Yunque Mts., Underwood & Earle *1087, 1141* (NYBG), C. W. Wright *510* (TYPE) Herb. Berk. 1879 (Kew); *Costa Rica:* Puntarenas Prov., above Palmar Norte, GWM & ALW *8298, 8329* (SUI); *Panamá:* Barro Colorado Island, GWM & ALW *7300, 7303, 7335, 7529, 7785, 7815, 8507, 8393* (SUI).

The examination of type material was not satisfactory. While the material consists of eight sporophores, these are very small, averaging about 3 mm. and glued tightly to the sheet. Since this was type material, no complete sections were made. One hymenium smash was made. The abundant spores did not plump up in KOH solution and the hymenial organization could not be discerned. The gross morphological aspects fit well into the description given here, especially the hymenium color. The overall appearance was generally like that of our collections but smaller and without the thelephoroid aspect.

Burt mentions that Wright's collection notes refer to this species as white when collected. Of the several collections we made in Panamá and Costa Rica, none were white when collected, but rather pale ochraceous, with no great change between collection and drying.

S. pusiolum and *S. radicans* form a closely related complex within the stipitate Stereums. They are the only monomitic, clamp-bearing, gloeocystidiate, stipitate Stereums found so far. Their relationship to each other is discussed under *S. radicans.*

Stereum radicans (Berk.) Burt, Ann. Missouri Bot. Gard. *7:* 108. 1920.

Fructifications stipitate, fleshy-coriaceous, chalk-white when fresh, drying rather hard and brittle, turning Clay-Colored (R), streaked with dark brownish-purple lines, to completely brownish-purple, especially the hymenium, with age or when bruised; pileus thick, spathulate to flabelliform, sometimes dissected and lobed, longitudinally furrowed or smooth on upper surface, underside smooth or roughened, margin usually crenate, 10–350 × 12–125 mm., pileocystidia absent; stipe cylindrical to flattened, smooth to ridged, glabrous to slightly tomentose, caulocystidia absent, sometimes arising from a radicated base, 10–15 × 3–4 mm.

Pileus in section (645–)950–975 μ thick; hyphal structure monomitic, hyphae with clamp-connections, some with thickened walls, 2–3.2 μ in diam., certain of the contextual hyphae becoming filled with brownish-yellow, refractile material; basidia cylindrical-clavate, 27–33 × 3–5 μ, with two to three, rarely four, sterigmata, each 4–6.4 μ long; gloeocystidia more or less cylindrical-clavate, usually 56–80 × 6–7 μ, sometimes filled with a brownish-yellow refractile substance; amorphous brownish-yellow material within

and on the hymenium; irregularly subglobose to globose bodies present in hymenium and seem to arise by pinching off of hyphal tips; spores subglobose, pip-shaped, one to several-guttulate, usually with one large and several small guttulae, sometimes granular, (4.8–)6.4 μ; on wood.

SPECIMENS EXAMINED: *Panamá:* Prov. Panamá, GWM, *3111,* Barro Colorado Island, GWM *3179,* GWM & ALW *7325, 7478, 7484, 7521, 7653, 7697, 7715, 7729, 7890, 8443, 8468, 8695,* and one unnumbered collection, (SUI); *Colombia:* Sierra Nevada de Santa Marta, Dept. Magdalena, GWM *3762* (SUI).

TABLE 2. *Comparison of S. pusiolum and S. radicans*

Characters	*S. pusiolum*	*S. radicans*
Shape of fruit-body	Spathulate to flabelliform	Spathulate to flabelliform
Color of fruit-body	Pale ochraceous when fresh,[1] little change in drying; hymenium turning Deep Quaker Drab (R); pileus more yellowish when dry	Chalk-white when fresh, changing to clay colored with streaks of brownish-purple or entirely brownish-purple; hymenium turning purple-brown with age and when bruised
Stem	Usually short	Usually long
Substrate	Soil	Wood, buried and on surface
Thickness of pileus in section	395–400 μ	(645–)950–975 μ
Hyphal construction	Monomitic	Monomitic
Hyphae	Thin-walled with clamp-connections, some with thickened walls, 1.6–3.2 μ in diam.	Thin-walled with clamp-connections, some with thickened walls, 2–3.2 μ in diam.
Gloeocystidia	40–60 × 6–8 μ, cylindrical-clavate, usually filled with brownish-yellow material, also in hymenium	56–80 × 6–7 μ, cylindrical-clavate, usually filled with brownish-yellow material, also in hymenium and context
Basidia	27–32 × 4.8–6.2 μ, 3–4 sterigmata, 4–6.4 μ long	27–33 × 3–5 μ, 2–3(–4) sterigmata, 4–6.4 μ long
Spore-like bodies	Present in hymenium	Present in hymenium
Spores	4.8 μ, pip-shaped	(4.8–)6.4 μ, pip-shaped, one to several guttulate

[1] If Wright's field notes mean white instead of whitish, this would emphasize the color similarities between the two species.

In addition to the above localities, Burt lists Jamaica, Trinidad, Granada and British Honduras. From the above data it can be assumed that this species is widely distributed in tropical countries and of fairly common occurrence.

Burt (1926) is the only previous investigator to report gloeocystidia in this species. No doubt the failure to observe these structures was due to their cylindrical-clavate form which makes them resemble basidioles to a

certain degree. The thickened hymenium tends to obscure the origin of these structures but their contents are the kind generally associated with gloeocystidia. Burt (1926) also notes that the spores become slightly colored in the herbarium and suggests transferring *S. radicans* to *Thelephora*. Since there are collections in the Iowa herbarium which are several years old that do not show any color change, there seems to be little merit in this suggestion.

In comparing the descriptions of *S. pusiolum* and *S. radicans* certain similarities become evident. In table II, we see that the only differences between these two species are their color in the fresh and dried state, their color change, stipe length, substrate, pileus thickness in section, sterigmata number and spore size.

The color differences might be explained by what seems to be a localization of the pigment in the hymenium of *S. pusiolum*, whereas the pigment is diffuse in *S. radicans*. Actually, some specimens of *S. radicans* resemble *S. pusiolum* in color after they have dried and aged a while. Judging from other species of stipitate Stereums stipe length is of little, if any, taxonomic importance. The variability of substrate is no greater than that found in other species, noticeably *S. Ravenelii*. The thickness of the pilei of the two species cannot be explained on the basis of present collections, for there does not seem to be any overlapping in thickness. There is a definite overlapping in the matter of sterigmata number and spore size.

In comparing differences and similarities, there seem to be more significant similarities than significant differences. Further investigation and collection with accurate field notes will no doubt prove whether or not these two species are only varieties of each other or distinct entities. On the basis of present knowledge, it seems more likely that they are only varieties of the same species.

STEREUM HYDROPHORUM Berk., Ann. & Mag. Hist. I. *14:* 327. 1844. *Hymenochaete crateriformis* P. Henn., Hedw. *43:* 172. 1904.

Fructification stipitate, separate, drying Prout's Brown (R), faintly zonate; pileus coriaceous, infundibuliform, velvety because of very long brownish-yellow hyphae projecting from upper surface, with large coarse spines at the base of the pileus which are themselves hirsute; undersurface concolorous or with vinaceous tints, minutely setulose from brownish-yellow hyphae which project from the hymenium about 75 μ, sometimes incrusted at their apices; stipe cylindrical, expanded toward the base, densely hairy because of projecting thick-walled, brownish-yellow caulocystidia, 28–30 × 4–5 mm.

Pileus in section 500–600 μ thick; hyphal structure trimitic, skeletal hyphae 4.8–6.4 μ in diam., binding hyphae 3–4 μ in diam., generative hyphae with obscure clamp-connections, 2–3.2 μ in diam.; *basidia not seen;* thick-walled protruding brown hyphae, sometimes with terminal incrustations throughout the hymenium; spores even, hyaline, non-guttulate, 4.8 × 3.2μ, few seen; on wood.

SPECIMENS EXAMINED: *Dutch Guiana* (Surinam): Coppernam River, B. Maguire (SUI); *British Guiana:* Herb. Berk. 1879 (Kew); *Brazil:* Woods near Rio Negro, Herb. Berk. 1879 (Kew).

In all the specimens studied, no hymenial structures, other than the terminally incrusted, thick-walled, protruding, brown hyphae, were found. Burt reports neither cystidia nor gloeocystidia. Whether or not the protruding brown hyphae, which are also found in the context of the pileus, should be called cystidia must await further investigation. *S. hydrophorum* is the only stipitate *Stereum* thus far analyzed hyphally which is trimitic. The trimitic condition of its fruit-body sharply separates it from all other stipitate Stereums. Exactly what its relationship to other Stereums is must await additional information on other species of *Stereum,* both stipitate and non-stipitate.

STEREUM SURINAMENSE Lév., Ann. Sci. Nat. Bot. III. *2:* 209. 1844.

Fructifications stipitate, gregarious to crowded, occasionally caespitose by twos, rarely more, pilei coalescing, but stipes remaining distinct; pileus coriaceous, infundibuliform, glabrous, usually shining, lineate-striate or smooth, sometimes split along one side, drying hazel to tawny, older fructifications darker in color, faintly or strongly zonate, underside light Vinaceous Pink (R), margin more or less entire to dentate-fimbriate, 6–40 × 5–40 mm., pileocystidia absent; stipe cylindrical, drying concolorous or darker to Burnt Umber (R), smooth to slightly strigose, caulocystidia sometimes arranged into a palisade layer, projecting up to 30 μ from stipe surface, 5–8 × 1–2 mm., arising from a disciform, pulvinate, concolorous or darker mycelial pad 3–8 mm. in diam.

Pileus in section 300–400 μ thick; hyphal structure dimitic, skeletal hyphae 3–4 μ in diam., generative hyphae with clamp-connections, 2–3.2 μ in diam.; basidia cylindrical-clavate, 13–19 × 3–4.8 μ with four sterigmata, each 1.6 μ long; gloeocystidia subventricose to ventricose, occasionally more or less cylindrical, 24–56(–72) × 6–10 μ; spores even, hyaline, non- to several-guttulate, 3.2–4 × 1.6–2.4(–4) μ; on wood.

SPECIMENS EXAMINED: *Cuba:* Upper Caracusey Valley, Bros. Leon & J. Roca *8402* (NYBG); *Santo Domingo:* Consuelo, N. Taylor *176* (NYBG); *Panamá:* Barro Colorado Island, GWM *3097, 3160, 4066, 4144, 4526, 4615,* GWM & ALW *7016, 7056, 7287, 7305, 7411, 7681, 7803, 7845, 7860,* other unnumbered specimens (SUI); *Panure:* Herb. Berk. 1879 (Kew).

Burt (1920) reports *S. surinamense* as occurring in Trinidad in addition to some of the above locations. Lloyd (1913) says it is frequent throughout the tropics. *S. surinamense* is reported sometimes to be found in the petaloid condition (see Lloyd, Letter 48, p. 10, Myc. Writ. *4*). On this basis Lloyd believes it to be closely akin to *S. affine.* In his discussion of this species, Burt characterizes it as a stipitate *Stereum* with a conspicuous mycelial pad which occurs on wood and has gloeocystidia and a granular subhymenial layer. To these characters we must add the smaller spore size, only rarely above 3.4 × 1.6 μ, presence of caulocystidia, absence

of pileocystidia and its dimitic condition. The granular subhymenial layer stressed by Burt is the layer of generative hyphae.

STEREUM RAVENELII Berk. & Curt., Grevillea *1:* 162. 1873.

Fructifications stipitate, gregarious, separate or crowded; pileus coriaceous, infundibuliform, or sometimes split to a greater or lesser extent on one side giving it a flabelliform appearance, underside buff to vinaceous-fawn, often faintly zonate at margin, upper side reddish-brown, faintly zonate or azonate, more or less hairy because of loose hyphae on pileus surface, pileocystidia absent, 5–11 × 8–20 mm.; stipe concolorous with underside of pileus or slightly darker, cylindrical or somewhat flattened, no caulocystidia but loose wefts of hyphae may give tomentose appearance, 5–6 × 0.5–1 mm.

Pileus in section 375–570 μ thick; hyphal structure dimitic, skeletal hyphae 2.4–4.8 μ in diam., generative hyphae with clamp-connections, 2.4–3.2 μ; basidia cylindrical-clavate, 20–25 × 4–5 μ, with sterigmata 1.6–2.4 μ in length; gloeocystidia short-clavate, short-cylindrical, ventricose to subcylindrical, often long and flexuous, often extending beyond the hymenial layer, then often bending back into hymenium, 64–75(–123) × 6–8 μ; spores even, hyaline, none to 1-guttulate, 4.8 × 3.2 μ; on mosses, soil, and rarely wood.

SPECIMENS EXAMINED: *Alabama:* G. M. Peters *3814* Herb. Berk. 1879 (Kew); *Louisiana:* St. Tammany Parish, F. W. Pennell, 8–12–1912 (NYBG); *Cuba:* Sabana de Manacas, Bro. Leon *9280* (NYBG); *Panamá:* Chiriquí Prov., GWM *2056* (SUI), Barro Colorado Island, GWM & ALW *7103, 7259.*

South Carolina, Alabama, Mexico, Trinidad and Brazil are locations reported by Burt (1920). Lloyd (1913) reports it as a typical southern U. S. species. Obviously *S. Ravenelii* is both tropical and southern temperate in its distribution.

Burt (1920) reports the species as constantly infundibuliform, but Martin (1944) lists a collection in which both infundibuliform and flabellate specimens occur. Perhaps the flabellate forms are caused by a splitting of the pileus. The spore measurements given in this description agree more with Martin's measurements than with Burt's.

Martin (1944) and Burt (1920) believe *S. Ravenelii* to be closely related to *S. pergamenum,* whereas Lloyd (1913) relates *S. nitidulum.* Because of the absence of pileocystidia and the flexuous incurving gloeocystidia, *S. decolorans* seems to be more closely related to *S. Ravenelii* than *S. pergamenum.* Since *S. nitidulum* was not seen, no conclusions can be drawn regarding its relationship to *S. Ravenelii.*

STEREUM PERGAMENUM Berk. & Curt., Grevillea *1:* 161. 1873.

Fructifications stipitate, crowded or sometimes several united by their pilei with stipes distinct; pileus coriaceous, fan-shaped to spathulate or infundibuliform with one side split to, or almost to, the stipe, sometimes petaloid and split, faintly zonate or azonate, drying hazel to blackish-red,

with pileocystidia projecting from upper surface, more numerous toward base, 5–10 × 10–15 mm.; stipe concolorous, cylindrical or somewhat flattened, covered with numerous caulocystidia, some in tufts which are noticeable under hand-lens, projecting up to 115 μ from stipe surface, 7–8 × 1 mm., arising from a mycelial pad up to 4 mm. in diam. when on wood.

Pileus in sections up to 400 μ thick; hyphal structure dimitic, skeletal hyphae 2.4–5 μ in diam., generative hyphae with clamp-connections, 2.4–3.2 μ in diam.; basidia cylindrical-clavate, 24 × 4.8 μ, with four sterigmata, each 1.6–2.4 μ long; gloeocystidia subventricose to subcylindrical-attenuate, 24–29(–92) × 5–8 μ; spores even, hyaline, one to few guttulate, 4.8 × 3.2 μ; on wood, soil, and mosses.

SPECIMENS EXAMINED: *Alabama:* G. M. Peters *3814, 4527,* Beaumont *4629,* all in Herb. Berk. 1879 (Kew); *South Carolina:* Ravenel, Fungi Carol. Exsic. No. 4, 13 (TYPE), swamp *2630,* unnumbered collection from swamps, all in Herb. Berk. 1879 (Kew); *British West Indies:* Trinidad, Morne Bleu, F. J. Seaver *3169,* Ortoire River, F. J. Seaver *3321* (NYBG); *Nicaragua:* C. L. Smith 1893–1896 (SUI); *Colombia:* Sierra de Santa Marta, Dept. Magdalena, GWM *3671, 3721, 3725, 3743, 4920* (SUI).

S. pergamenum is listed by Burt (1920) as occurring also in Ohio, North Carolina, Alabama, Louisiana, Mexico, Cuba and San Domingo. The species is, therefore, tropical, subtropical and temperate in distribution.

Martin (1944) notes its variability as to size, stem attachment, color, length and hairiness of stem, as well as substrate. He also points out that the description of *S. tomentipes* Overholts would fit some of the specimens of *S. pergamenum.* No specimens of *S. tomentipes* were seen and it is, therefore, impossible to determine *S. pergamenum's* relationship to *S. tomentipes.* Burt suggested that perhaps *S. pergamenum* and *S. nitidulum* are related. From the information presented here, *S. pergamenum* seems related to *S. Ravenelii* by virtue of its rather long and flexuous gloeocystidia. Because it bears pileo- and caulocystidia, *S. pergamenum* is also related to *S. elegans.* Whether specimens are caespitose or not does not seem to be an important character, since this seems to be a result of spatial closeness rather than an inherent character.

STEREUM ELEGANS (Mey. ex Fr.) Fr. Epicris. 545. 1838. *Thelephora elegans* Mey. ex Fr. Syst. Myc. *1:* 430. 1821. *Stereum flabellatum* Pat. Soc. Myc. Fr. Bull. *16:* 179. 1900.

Fructifications caespitose or occasionally separate and usually crowded, white when fresh with stipes and center brownish or perhaps red of some shade, stipes usually distinct; pilei membranous, drying coriaceous, brittle, glabrous, faintly zonate or azonate, turning Mahogany Red (R) to Chestnut (R) to reddish bay and, sometimes, translucent, pileocystidia not noticeably more numerous toward junction of pileus and stipe, margin more or less deeply incised or lobed, underside whitish when hymenium is present, 35–40 × 5–30 mm.; stipe cylindrical or somewhat flattened, drying darker red-brown than pileus, hairy because of caulocystidia projecting up to

150 μ from stipe surface, borne singly or in tufts, 1–10 × 1–2 mm., arising from a more or less well-developed mycelial pad 2–8 mm. in diam. which is common to several stipes or to each individual.

Pileus in section 250–450 μ thick, hymenium sometimes thickening or occasionally replaced by chlamydospores with flattened ends, arising from hyphal tips, 3.2–4.8 μ in diam.; hyphal structure dimitic, skeletal hyphae 3–5 μ in diam., generative hyphae with clamp-connections, 2.4–3.2 μ in diam. in subhymenium, slightly larger, 3–5 μ in diam., in context; basidia cylindrical-clavate, 30–32 × 4.8–6.4 μ, with four sterigmata, each 1.6–3.2 μ long; gloeocystidia ventricose to subcylindrical, rarely with capitate head, (16–)48–64(–104) × 4.8–10(–16) μ; spores even, hyaline, none to one guttulate, 4.8 × 3.2 μ; on wood.

SPECIMENS EXAMINED: *Jamaica:* A. E. Wright (NYBG); *Cuba:* Servilla Estate near Santiago, N. Taylor *260,* Sierra del Caballete, Santi-Spiritus Mts., F. Leon & Clement *6510* (NYBG); *Puerto Rico:* Mayaguez, Santiago, B. Lopez *17* (NYBG); *Dutch Guiana* (Surinam): Jacob Samuels *33* (NYBG); *British Guiana:* Kamakusa, Herbert Leng (NYBG); *Panamá:* Barro Colorado Island, GWM & ALW *7470, 7701, 8671,* Rio Sardinilla, Canal Zone, GWM & ALW *7563* (SUI); *Colombia:* Sierre de Santa Marta, Dept. Magdalena, GWM *3574* (SUI).

Among our specimens from Panamá, a collection was found to be bearing chlamydospores similar to those described by Martin (1939) for *S. flabellatum* Pat. as well as basidiospores. The field notes on this collection listed it as white when fresh, as is *S. flabellatum,* according to Patouillard. Collections of *S. flabellatum* and *S. elegans* were closely compared and, with the exception of the pellucid condition of the dried pileus in *S. flabellatum,* were found to be identical. The transparency of the dried pilei of *S. flabellatum* can be explained when it is remembered that the entire hymenium is replaced by chlamydospores and is, therefore, thinner. Why the hymenium is replaced by chlamydospores is not known. Perhaps unfavorable weather conditions or injury by insects, slugs, etc. will cause the production of chlamydospores.

Burt (1920) describes *S. elegans* as infundibuliform but Martin (1944) lists it as rarely infundibuliform. The exact shape of the pileus is not always easy to determine. Generally, it seems to be flabellate. Burt reports spore size as 3.5–4.5 μ and Martin reports them as 5–5.1 × 3–3.5 μ. The spores are not globose as reported by Burt, but are elongate-oval.

SUMMARY

1. A microscopic analysis of the component parts of the basidiocarp seems to be a valuable tool for the determination of relationships among the stipitate Stereums. Using this method, relationships which have been previously overlooked are brought to light.

2. It is suggested that *S. aurantiacum* and *S. diaphanum* might be varieties. The same suggestion is offered as regards *S. pusiolum* and *S. radicans.*

3. It was found that *S. cyphelloides, S. aurantiacum* and *S. diaphanum* form a homogenous group within the stipitate Stereums. This group is characterized by its lack of clamp-connections and gloeocystidia and its monomitic hyphal construction.

4. *S. pusiolum* and *S. radicans* are the only other stipitate Stereums investigated which are monomitic, bear clamp-connections and have gloeocystidia. These species form a second group of related forms.

5. With the exception of the trimitic *S. hydrophorum* whose relationship is vague, all other stipitate Stereums discussed here are dimitic with skeletal hyphae, bear clamp-connections and are gloeocystidiate.

6. *S. flabellatum* has been found to be only a chlamydospore-bearing phase of *S. elegans.*

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BULLETIN OF THE TORREY BOTANICAL CLUB
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GROWTH PATTERNS OF EXCISED TOMATO ROOTS

ADDISON E. LEE

Excised roots are being used increasingly as experimental material for studies of metabolic pathways (Bonner & Buchman 1938, Dormer & Street 1949, Boll 1951, Norton unpublished data), for evaluating effects of growth-modifying substances (White 1943a, Bonner & Koepfli 1939, Bonner 1940, Robbins 1942, Naylor & Rappaport 1950, Almestrand 1951), and for investigating the character of genetic differences (Robbins 1941, Whaley & Long 1944, Boll 1951, Skinner 1952). Variations in results and in interpretations make desirable more detailed knowledge of the growth patterns of the roots being investigated. It has long been observed by workers in this field that the growth patterns of such roots vary not only from one genetic stock to another but with changes in the culture medium or in the techniques by which the roots are cultured.

It was the purpose of the study reported here to determine the growth patterns of excised tomato roots of three different origins cultured under controlled conditions and the extent to which these patterns are influenced by differences in the age and position of the apices before excision.

Materials and methods. The three root clones used were from the University of Texas; *Lycopersicon esculentum* Mill., line 151; *L. esculentum*, line 103; *L. pimpinellifolium* Mill., line 154. The roots were excised from stock cultures which had been grown for more than 30 passages in White's standard medium (1943b). The same medium was used throughout the experiment. Unless otherwise stated, the procedure followed in setting up the cultures was as follows. Ten mm. tip portions of lateral roots were grown in 50 ml. of medium in 125 ml. flasks. The flasks were placed in a culture room in the dark at a temperature of $28 \pm 2°$ C., for seven days. On the seventh day, two to four segments, each bearing four to six lateral roots, were cut from the center or basipetal section of the cultured root. The excised segments were grown for four or five days, until the laterals had reached a length of 30–50 mm. This passage is referred to as the segment passage. At the end of this passage, 10 mm. tips were cut from lateral roots of relatively uniform length and placed in fresh medium. These root tips were grown for seven days; this passage is referred to as the tip passage.

The results recorded are those of a single run of each of the experiments described. These results are, however, supported by repeated independent measurements of various aspects of the growth patterns described as well as by general observations which have been a part of other studies made with these same root lines.

Results. Growth of the main axis and emergence and growth of lateral roots in the tip passage:—Twenty cultures of each line were established from the tips excised from lateral roots of a segment passage. The length of each root and its laterals and the position in which the laterals appeared were determined daily for four days and again on the seventh day. These measurements were recorded in the form of scale diagrams which indicate both length and positional relationships (fig. 1). The first four measurements were made after pulling the roots up on the side of the culture flask,

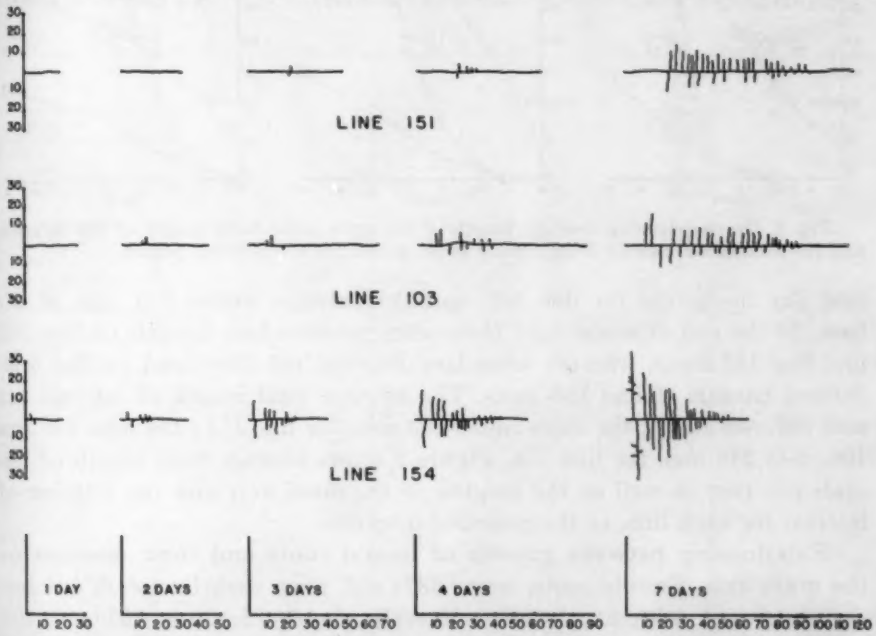

FIG. 1. Scale diagrams of typical roots made after daily measurements for four days and at the end of seven days. These diagrams show the length of the main axis, and the position of the laterals along the main axis as well as their lengths at different times and the time at which the laterals become visible during a seven-day growth period.

but by the fifth day this was not practicable. Seventh-day measurements were made on roots removed from the culture flasks.

During the first day in culture roots from each line approximately doubled in length. In seven days, the main axis of line 151 and line 103 roots grew in excess of 100 mm. while those of line 154 grew only about 60 mm.

Laterals appeared between the first and second day on roots of lines 151 and 103, with some variation among individual roots. By the second day more roots from line 103 had laterals than did those of line 151; furthermore, laterals of line 103 developed closer to the basal end of the main axis than did those of line 151. Lateral roots consistently appeared during the

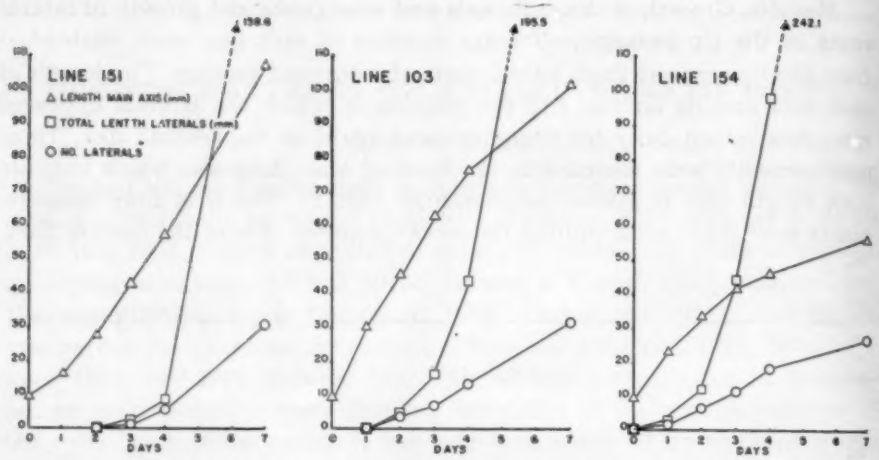

FIG. 2. Graphs showing average length of the main axis; total length of the laterals, and the number of laterals from twenty roots grown for a seven-day period.

first day in culture for line 154, and then always within 2–3 mm. of the base. At the end of seven days, there were no secondary laterals on line 151 and line 103 roots, whereas secondary laterals had developed on the first-formed laterals of line 154 roots. The average total length of laterals per root differed among the three lines: 159 mm. for line 151; 196 mm. for line 103; and 242 mm. for line 154. Figure 2 shows average total length of laterals per root as well as the lengths of the main axis and the number of laterals for each line, at the recorded intervals.

Relationship between growth of lateral roots and their position on the main axis. Twenty roots, seven days old, from each line were cut into segments, each with five to seven laterals (fig. 3). In lines 151 and 103, segments immediately basipetal to the tip without visible laterals were cultured. In line 154, the laterals were so close to the tip that no lateral-free

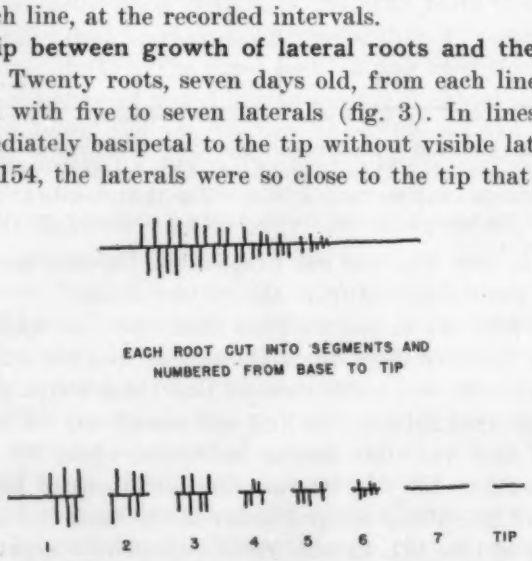

FIG. 3. Diagrams showing method of cutting root into segments and numbering them for studies on the effect of position on the potential growth of lateral tips.

segment was used. The segments, numbered from the basal end toward the tip, were placed individually in flasks and cultured for seven days. The lengths of the laterals were determined daily and averages for each segment were calculated. There was considerable variation in the growth of the individual laterals on a given segment. The average growth of laterals on the different segments also varied from root to root, but followed a definite pattern for each line (fig. 4).

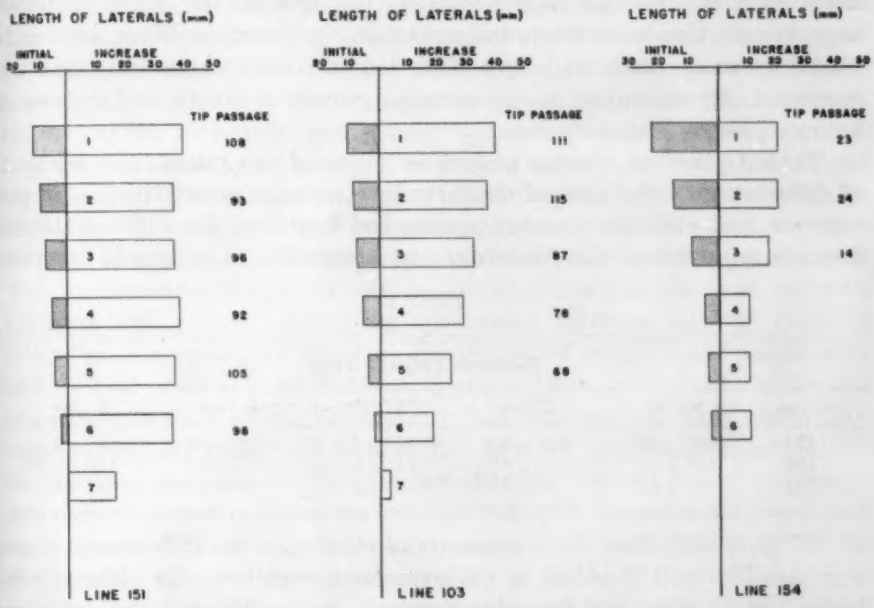

FIG. 4. Histograms showing the average length of laterals from the different segments numbered from base to tip (histograms on the left of each vertical line) and the average length of these laterals after growth in a seven day segment passage (histograms on the right of each vertical line). The numbers at the right of each bar in the histogram represent the growth in length of tips taken from laterals in each of these positions after a seven-day segment passage.

At the end of their segment passage of seven days, representative tips were taken from the laterals and grown for seven days. The average lengths of main axes in these tip passages are given at the right of the histograms in figure 4.

Relationship between segment age, individual length of laterals and subsequent growth of the lateral root tips. The data suggest differences among the three lines in the relationship between the position of laterals along the main axis of the root and the potential growth of their tips.

In these roots it is difficult to separate fully from each other consideration of position, age, and length. In general, the more basipetal laterals are older, and the older laterals are longer. To an extent, however, it is possible

to evaluate the relative importance of length, age, and position considerations in the subsequent growth of a tip.

In each of the lines lateral tips from segment two grew as well as those from segment one in tip passages (fig. 4). For this reason, only segments one and two were used to investigate the influence of segment age and/or individual lateral length upon subsequent growth of lateral tips. Twenty segments from each of the three lines were grown respectively for two, three, four, five, and six days in segment passages. At the end of each passage, twenty tips were taken and grown in tip passages. When each individual tip was excised, the length of the lateral from which it was taken was measured. At the end of the tip passage, growth in length and number of laterals produced were recorded.

Table 1 gives the average growth in length of tips taken from segments of different ages. For each of the three lines average growth in the tip passage was best when the segment passage had been four days. When the differences in growth of tips from four day segments were compared by means

TABLE 1

	Segment Passage Time				
Line	2 Day	3 Day	4 Day	5 Day	6 Day
151	107 ± 3.8	103 ± 3.8	120 ± 2.8	98 ± 3.0	92 ± 4.3
103	104 ± 4.2	109 ± 3.8	115 ± 4.2	101 ± 3.2	100 ± 4.8
154	57 ± 4.8	48 ± 3.3	68 ± 3.7	43 ± 4.5	42 ± 4.1

of "t" tests with those from segments of other ages the differences showed a probability of 0.02 or less in all instances except two; the difference between tips of three and four day segments in line 103 and the difference between tips of two and four day segments in line 154. In these instances the probability was 0.1. It seems quite clear, therefore, that the age of the segment from which a tip is taken is of considerable importance in obtaining optimum growth of the tip. The data were analyzed further to determine the relationship between the growth of a tip and the length of the lateral from which it was taken. No correlation was found, but in general, growth of the tips was better when the laterals from which they were excised were between 20 and 60 mm. long.

Discussion. Excised tomato roots are simple organs and a study of their morphological differences involves fewer variables than does the study of most morphological differences in whole plants. The existence of such differences as those reported here in excised roots grown under comparable conditions is evidence for genetic determination. The differences include—total growth in length of the main axis, rate of main axis growth, emergence time of the laterals, position of the laterals along the main axis, length of the laterals, and the presence or absence of secondary laterals—during a

given growth period. The lines of *L. esculentum* (103 and 151) differed more from that of *L. pimpinellifolium* (154) than they did one from the other. The data presented in this study shed no light on the mechanism controlling these patterns. However, control of growth patterns such as are described here has been related by other workers to indole acetic acid (Leonian & Lilly 1937, White 1943b), the level of potassium in the medium (White 1943b), and the kind and concentration of sugar (Dormer & Street 1949, Street & McGregor 1952). Modifications in growth have also been noted as a consequence of the action of various growth inhibiting substances.

The data suggest that the position of the lateral when excised bears more direct relationship to subsequent growth in some lines than in others. In line 151 the pattern of development was such that the laterals on sectors 1 through 6 made approximately equivalent growth in both segment and tip passages. This observation suggests that the development conditions essential for optimum growth of laterals were already established in segments close to the main apex and that once established they were not greatly modified. Inasmuch as the initial total length of laterals of the most basipetal segments was greater, equivalent subsequent increase actually indicates somewhat less growth of these sectors compared to the more apical ones. Line 103 presents a quite different picture. Here, growth of the laterals was better in each of the successively basipetal sectors. This observation suggests that the conditions making for optimum growth obtained only in the most basipetal sectors. The pattern of lateral growth in line 154 was so different from that in either lines 151 or 103, that to obtain anywhere near equivalent growth, this line had to be handled in a shorter segment passage than was used in the experiment reported in figure 4. Direct comparisons between it and the other two lines in respect to the growth pattern of the laterals could not be made. Among the possible explanations of these differences in the growth of the laterals are differences in time of maturation of the laterals which may in turn reflect differences in influences from the main apex.

SUMMARY

1. The growths in culture of excised roots of clones from three different tomato lines (representing two species) were compared in a single medium. Among these lines, differences were found in the length of the main axis of the roots, the rate of growth of the main axis, the emergence time of laterals and their growth in relation to their position on the main axis, the total length of the laterals and the presence or absence of secondary laterals. The number of laterals produced was similar for each of the three lines, and the overall growth patterns of the two lines representing the same species were more similar to each other than to the representative of the second species.

2. The relationship between the growth of lateral roots and their position on the main axis was investigated and found to vary among the three lines. The two most basipetal segments containing laterals were found to grow best for two of the lines while in the remaining line segments taken from any position along the main axis bearing visible laterals grew equally well.

3. Studies were also made to determine the relationship between the potential growth of a tip and the age and/or length of the lateral from which it was excised. Optimum segment age was found to be four days in all lines. No correlation was found between the growth of an excised tip and the length of the laterals from which it was taken. Best growth was obtained from the tips of laterals which were within the limits of 20–60 mm. in length.

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GROWTH OF THE MAIN APICES OF EXCISED TOMATO ROOTS

ADDISON E. LEE

Tomato root cultures are commonly maintained by repeated subculturing of lateral root tips. This procedure involves the periodic replacement of one root apex by another. Its use has left open the question of whether or not a given meristem is capable of indefinite growth. Boll (1951) was unable to subculture the main apex of excised roots of the lines of tomato with which he was working for more than a few passages when a seven-day tip passage was used. He reported an increase in total growth of the root when a shorter passage was used, but this treatment failed to provide the conditions necessary for potentially unlimited growth of a given apex. Street and Roberts (1952) have presented evidence to show that, under certain conditions, growth from the main apex ceases in medium which still supports active growth from lateral meristems, and that there are internal reciprocal influences between the main axis meristem and the lateral meristems. White (personal communication) has recently reviewed some of the records of his earlier root culture work and found that in certain instances he cultured single meristems through at least 20 passages, that is through continuous periods of somewhat less than half a year. This was in routine stock cultures where no special effort was made to use primary apices, these being chosen only because they provided what appeared to be the best material for subcultures. Street, McGonagle, and Roberts (1953) have shown that individual root tips of their line of *Lycopersicon esculentum* could be subcultured through 15 seven-day passages without decline in mean growth values in a medium containing 1% sucrose, while those in a medium containing 2% sucrose did not survive beyond 4–7 passages. These authors reported that the duration of activity of the main axis meristem of their line of *L. pimpinellifolium* could also be extended by adjustment of the sucrose concentration of the medium.

The experiences reported from various laboratories indicate that the main apices of tomato roots of different lines may have different capacities with respect to their growth potentials and further that these capacities vary with conditions of treatment. This paper presents additional evidence concerning the potential growth of main apices of three clones of tomato roots.

Materials and methods. Clones of excised tomato roots designated University of Texas lines 151, 103, and 154 described in a previous paper (Lee 1954) were used. The roots had been maintained in stock cultures

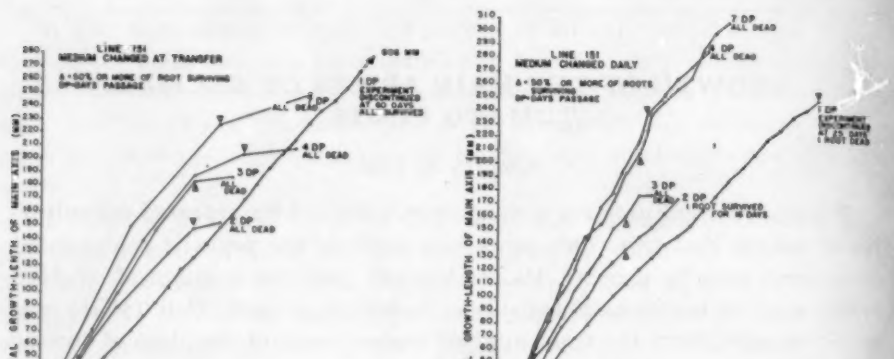

Fig. 1

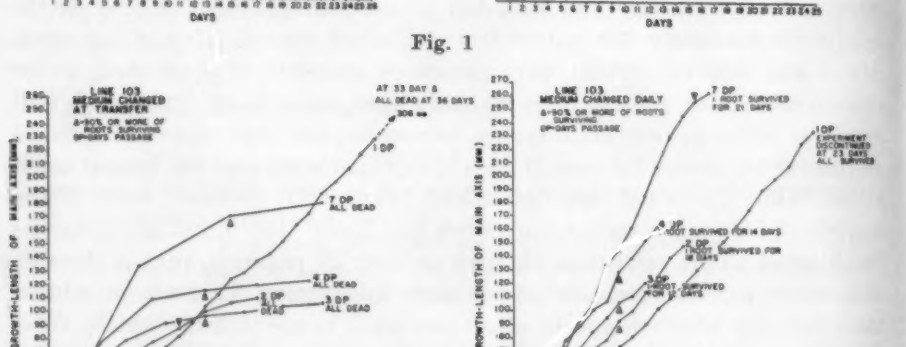

Fig. 2

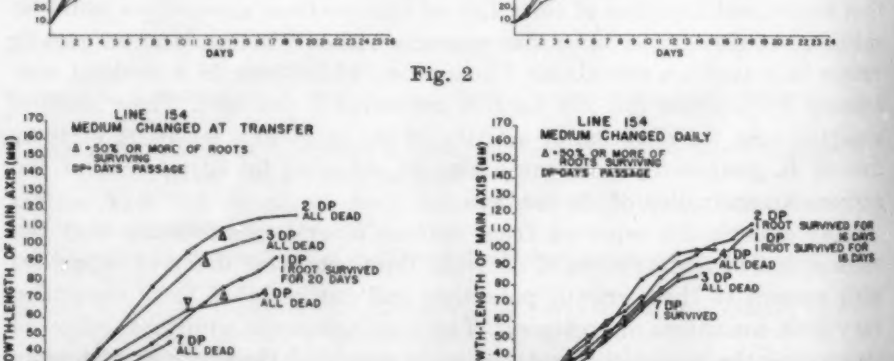

Fig. 3

for several months by alternating seven-day tip passages and four-day segment passages. The roots were grown individually in 125 ml. flasks containing 50 ml. of White's medium (1943). Five treatments were set up for each line, ten roots in each treatment. In the first treatment, subcultures of 10 mm. main apices were made daily; in successive treatments subcultures were made at two, three, four, and seven-day intervals. At each subculture, growth measurements were made, the apices were excised and placed in fresh medium, and the basal parts of the roots were discarded. Each treatment was carried out three times. In the first two times, the roots excised were transferred to fresh medium at the time of subculturing. The third time the procedure was modified so that the roots of each treatment were transferred into fresh medium and measured daily.

Microscopic examinations were also made of tips taken directly from the laterals in a segment passage and of tips which had been growing for one, two, three, four or five days. These were killed and fixed in F.A.A. and cleared in lactophenol. The lengths (parallel to the long axis of the root) of 10 epidermal cells were determined for each of 10 roots at distances of 1, 2, 5, 10, 20, and 30 mm. from the tip as were those of inner cells of the "promeristem" region.

Results. The results in terms of total growth and growth rate of the main apices and their survival are presented in figures 1, 2 and 3. Each point on the graph represents the average growth in length of the number of roots surviving at the time of measurement. Thus the initial points are for ten roots and the other points are averages for two or more roots. The time at which half the roots were dead in a given treatment is also indicated. In general, when the roots started to die all of them in a given group died within a few days of each other. The instances of single root survival beyond the curves plotted have been indicated and in these instances the single roots surviving died in a very few days. Roots were considered dead when they had made no growth over two transfer periods or showed signs of deterioration.

Measurements of cell lengths (table 1) varied little from one line to another. In all lines, "promeristem" cells were on the order of 9–10 microns in length. Epidermal cells were increasingly longer away from the tip up to 5 mm. and had reached their maximum length (100–125 microns) between 5 and 10 mm. from the tip. At all points measured less than 10 mm. from the tip, the epidermal cells of root tips grown for one day were considerably shorter than those of tips just excised from the laterals or those grown for two to five days.

Line 151. Roots of line 151 given a one-day passage grew for 60 days with no diminution in growth rate and with a very high percentage of survival. The experiment was discontinued at 60 days, but there was no

reason to assume that they could not have been cultured indefinitely in this treatment. The apices had made a total growth in length of more than 600 mm., practically double that made in any of the other treatments. Roots given four and seven day passages grew for approximately 20 days before all were dead. When the medium was changed at the transfer time, they made total growth of 245 and 206 mm., respectively. When the medium was changed daily, the total growth reached by the roots in the four- and seven-day passages increased to about 300 mm. and exhibited essentially parallel growth rates. In the treatments using two- and three-day passages,

TABLE 1

Line & Days Cultured	AVERAGE LENGTH (μ) OF CELLS AT INDICATED DISTANCES FROM TIP						
	"Promeristem" Cells	1 mm.	2 mm.	5 mm.	10 mm.	20 mm.	30 mm.
LINE 103							
0	9 ± 0.8	48 ± 5	79 ± 6	96 ± 2	120 ± 2		
1	8 ± 0.6	22 ± 2	49 ± 5	64 ± 2	80 ± 3	99 ± 3	
2	9 ± 0.3	40 ± 4	80 ± 5	94 ± 4	100 ± 2	101 ± 2	101 ± 4
3	10 ± 0.4	31 ± 3	64 ± 5	97 ± 3	106 ± 3	107 ± 4	109 ± 5
4	11 ± 0.3	29 ± 2	60 ± 6	102 ± 4	113 ± 3	112 ± 3	113 ± 5
5	10 ± 0.3	29 ± 2	74 ± 2	97 ± 2	101 ± 1	102 ± 1	
LINE 151							
0	11 ± 1.5	46 ± 4	80 ± 3	92 ± 2	93 ± 1		
1	9 ± 0.6	34 ± 4	63 ± 5	84 ± 6	82 ± 6	114 ± 8	
2	8 ± 0.4	30 ± 2	62 ± 8	100 ± 9	119 ± 5	104 ± 7	121 ± 4
3	10 ± 0.4	26 ± 2	64 ± 2	109 ± 5	118 ± 2	121 ± 5	117 ± 2
4	10 ± 0.3	26 ± 2	47 ± 4	98 ± 2	110 ± 2	112 ± 1	113 ± 1
5	10 ± 0.4	36 ± 2	72 ± 7	96 ± 5	102 ± 2	102 ± 1	115 ± 3
LINE 154							
0	14 ± 0.3	86 ± 4	105 ± 5	110 ± 3	118 ± 10		
1	9 ± 0.6	23 ± 2	53 ± 4	69 ± 8	91 ± 9	92 ± 6	
2	9 ± 0.4	39 ± 6	38 ± 5	98 ± 6	121 ± 5	122 ± 7	113 ± 5
3	10 ± 0.9	34 ± 4	80 ± 10	99 ± 7	123 ± 7	133 ± 3	134 ± 2
4	11 ± 0.5	32 ± 2	84 ± 4	101 ± 3	114 ± 4	113 ± 4	116 ± 4
5	9 ± 0.4	43 ± 4	75 ± 3	99 ± 2	101 ± 1	101 ± 3	

all the roots were dead within fifteen days or less. At this time total growth was approximately 180 mm. A comparison of the growth rates for the different passage treatments indicated that those roots subjected to a one-day passage showed the lowest rate and those given successively longer passages showed, during the early part of their growth, successively higher rates except that roots given a four or seven-day passage and placed in fresh medium daily exhibited nearly parallel rates.

Line 103. Roots of line 103 given a one day passage time and the medium changed at the time of subculture, continued their growth for 36 days, at which time they had reached a total growth in length of 306 mm. None of the roots survived beyond the 36th passage. There was, however, no diminution in the growth rate throughout the period during which the roots sur-

vived. Roots of this line subjected to all of the other treatments showed an early diminution of growth rates. All died within 21 days. Growth rates for the different treatments of roots from line 103 were comparable to those from line 151. Roots given one-day passages grew at the lowest rate while those given successively longer passages grew at somewhat higher rates during the early period of growth. When the medium was changed daily the chance for survival for those in the two, three, four, and seven-day passages was not increased. Growth rates of the roots during the period of survival however, remained almost unchanged, with the result that each of them made a somewhat greater total growth during this period than did roots subjected to the same treatment when the medium was changed at the transfer time. For example, roots grown in medium changed only at the transfer time in seven-day passages reached a total growth of approximately 180 mm. while those given the seven-day passages when the medium was changed daily reached a total growth on the order of 260 mm. The differences in total growth of roots in two, three, and four-day passages were proportionately less, but roots grown in medium which was changed daily consistently showed a higher total growth in length compared with those in the medium changed only at the transfer time.

Line 154. The growth of roots from line 154 exhibited more variations from one experiment to another than did the other two lines. In line 154, all of the roots in the one-day passage were dead within a 20 day period. In contrast to the roots of the other two lines, those of line 154 in four and seven-day passages showed no better survival than those given two and three-day passages.

Discussion. The survival of the main apex of the different lines varied considerably. In line 151 it appeared to be possible to culture the main apex indefinitely if it were given a one-day passage, compared to a possible culture period of 20 days or less if given a longer passage. The potential growth of the main apex of roots from line 103 was extended considerably in the one-day passage compared to longer passages but not beyond 36 days. The survival of the main apex of line 154 roots was extended slightly by a one-day passage treatment but not to the extent shown by the other lines. Differences in amount of total growth obtained under these conditions for the three lines, paralleled their survival potentials.

Street, McGonagle, and Lowe (1951) have shown that certain changes occur in the medium as a result of the prolonged growth of a root. These changes include an increase in pH and the possible accumulation of products in the medium which they refer to as "staling." These authors have shown that staling is responsible for some decrease in the growth of excised roots in culture. The results of the experiments reported here are in agreement with those of Street, McGonagle, and Lowe. Roots given a four or

seven-day passage treatment attained a considerably greater length when the medium was changed daily than did those in which the medium was changed at the end of four or seven days. Roots given a two or three-day passage treatment made little or no more growth when the medium was changed daily but they did grow at a faster rate during the later part of their survival period. On the other hand, the medium staling factors were not the only factors involved in producing these growth differences. If the medium staling factors were the only important ones, those roots given a four-day passage in medium changed at transfer time would have grown better than those in the seven-day passages. Furthermore, changing the medium daily had no appreciable effect on the potential survival of the roots regardless of the passage treatment. It may also be noted that the staling factors had a more marked effect on roots of line 151 and 103 than on roots of line 154.

The results of the experiments described here furnish some additional evidence concerning the possibility of assuring the indefinite growth of the root apex. Since the growth of the root apex can be extended greatly by the use of a one-day passage technique, it would seem unlikely that the failure of the root apex to grow after subculture would be due to the exhaustion of some essential substance in the root. Since the passage time was altered and the medium was not, it would also appear that the failure of the root apex to grow indefinitely was not due to any determinate character of the meristem. On the other hand, the distinct differences among the three lines with respect to the potential growth in the different treatments suggests that inherent factors are involved in the survival of the main apex on subculture. While the data shed no light on the nature of the factors controlling the growth potential of the root apex, they clearly suggest that so far as survival is concerned there is some influence from the basipetal or more mature regions of the root which affects the growth potential of its meristem. It has been shown in previous work (Lee 1954) that the time of the lateral root emergence varies among the lines being investigated, those of line 154 appearing during the first day after excision and those of lines 151 and 103 appearing between the second and third day after excision. Root tips of lines 151 and 103 given a one-day passage never formed laterals, while those of line 154 did form laterals. These observations suggest that the extended growth period of the apices from lines 151 and 103 may have been related to the absence of laterals formed by these roots.

The data suggest that factors controlling rate of growth of the main apex and those controlling survival are not directly correlated. In general, rate of growth was higher with longer passages, while the survival potential was fairly constant for all passages longer than one day. The differences in rate of growth among the different treatments involve a number of considerations. If there is an influence of wounding involved, it might be sup-

posed to be greater in roots given a one-day passage as compared to ones given longer passage. It has been observed that a "lag" period of growth may occur in these roots. Such a lag period following excision would be cumulatively greater in roots given a one-day passage than in those given longer passages. The influence exerted by the laterals is possibly involved in these different growth rates and could be related to the production and distribution of auxin by both new and old meristems.

The cell measurement data do not indicate appreciable differences in ultimate epidermal cell size either among the three lines or among the different treatments. The data do indicate that during the first day after excision, cell division occurs in the epidermis over almost all, if not all, the length of the 10 mm. segment. This is indicated by the fact that at 1, 2, 5, and perhaps even 10 mm., from the tip, the epidermal cells were smaller in the root tips one day after excision of the segment than at the time of excision or, in most instances, than in root tips grown for more than one day. During the first day the enlargement of cells apparently extends over nearly all, if not all, of the root. After one day, cell division and enlargement is apparently progressively restricted to the region much nearer the apex. Inasmuch as the roots were still growing at the end of the fifth day, it can probably be assumed that cell divisions were continuing in the meristematic region and that these were accompanied by the enlargement of cells back as far as 2–5 mm. from the tip. Street and McGregor (1952) found cell elongation in the roots they observed to be complete within a distance of less than 3 mm. from the tip. This is a somewhat shorter distance than reported here, at least for those roots grown only for one day.

Whether the initial stimulation and the accompanying cell enlargement results from the wounding at excision or from the removal of inhibiting factors when the tip is removed from its association with an older part of the root is not clear. The cells so stimulated do not enlarge beyond the normal limit of epidermal cells in the various lines. Hence, in terms of enlargement an actual stimulation appears less likely. Observations reported by Street and Roberts (1952) and general observations in this laboratory clearly suggest that older tissues exert an inhibiting influence upon the growth of root tips. It seems more likely that the extended cell divisions characteristic of the first day after excision relate to the removal of inhibiting influences rather than the consequences of wounding.

SUMMARY

1. The total amount and rate of growth, and survival of root apices from three lines of tomato were compared in treatments which involved subculturing the main apex at the end of one, two, three, four, and seven days.

2. Although there was considerable variation among the three lines, a

greater total amount of growth was recorded for apices of all lines when subcultured at the end of one day.

3. In general, the rate of growth at the beginning of the treatment was higher for those roots excised after longer passages. During the later period of treatment, the growth rate of roots excised after longer passages declined rapidly and the roots failed to survive beyond at most a period of 21 days (or less). The rate of growth of roots excised after passages longer than one day, in medium which was changed daily, declined less than the rate of those in medium changed only at the time of transfer. The survival was not increased by changing the medium daily.

4. All of the roots of one line given a one-day passage treatment survived for 60 days without diminution in growth rate and thus it is presumed that they could have been subcultured indefinitely. In another line, subcultures were made for 36 days without diminution in growth rate, but all of the apices died between the 33rd and 36th day. In the other line survival was increased very little, if any, by the use of the one-day passage treatment.

5. Whatever are the factors controlling the growth potential of the root apex, it is clear that there are internal influences from the basipetal or mature regions of the root. These influences affect cell division and enlargement. They appear to be related to the presence or absence of lateral roots.

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BULLETIN OF THE TORREY BOTANICAL CLUB

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TORREYA

ARENARIA PATULA IN PENNSYLVANIA

Arenaria patula Michx. was collected in Carbon and Northampton counties in Pennsylvania on July 26, 1952 and in Lehigh County in Pennsylvania on June 15, 1953. These collections were made along or closely adjacent to the Lehigh River in the general vicinity of Lehigh Gap in the Blue or Kittatinny Mountains which is a ridge of Silurian sandstones and conglomerates belonging to the Appalachian System. Here Northampton and Lehigh counties lying southward from the mountains have the Lehigh River as a dividing line. The northern boundary of both counties is a line whch follows along the crest of the mountains and Carbon County adjoins both of the counties on the north.

The plant had been noted from an automobile in Lehigh Gap in Carbon County for two or more years prior to its collection. In 1953 on May 23rd, the plant was beginning to bloom, it had approached full bloom by June 15th, and on June 20th it was apparently at the height of its bloom and quite conspicuous. An effort was then made to ascertain something of its local frequence and abundance. It was observed to be present in its greatest frequence and abundance along the Lehigh River at Palmerton in Carbon County especially perhaps about the works of the New Jersey Zinc Company, on and about the hill of Clinton red shale on which in part the town of Palmerton is built and along the closely adjacent valley of Aquashicola Creek, all of which area is at or very closely adjacent to Lehigh Gap.

At places about the New Jersey Zinc Company works there were white sheets of the blooming plant as there were on the rather bare, much eroded slopes of the hill of Clinton red shale. The fallow, flat, meadowy areas along the Aquashicola Creek were almost solidly white with the sheets of the blooming plant.

Three small, very closely adjacent occurrences of the species have been located in Lehigh County at Lehigh Gap but it has been observed generally to occur along the Lehigh River in Northampton County for a distance of approximately 2⅜ miles downstream from Lehigh Gap and in Carbon County to extend upstream from Lehigh Gap for a distance of approximately 3⅞ miles as well as to extend eastward from the Lehigh River in Palmerton, Aquashicola and the valley of Aquashicola Creek for a distance of approximately 1¾ to 2 miles. Farther upstream in Carbon County for a distance of approximately 6½ miles to Mauch Chunk and beyond the plant has not yet been detected though looked for in the many favorable habitats that occur.

No published references have been seen of any occurrences of the species in Pennsylvania, which is not very closely adjacent to the range of distribution noted for the species by Dr. Merritt L. Fernald in Gray's Manual of Botany, Eighth Edition, as "Limestone-barrens, cliffs and open woods, s.O. to e.Kans., s. to Ala., Ark. and Tex. Late Apr.–Jun." nor are any such occurrences in Pennsylvania otherwise known. How and when the species was introduced in the area is also not presently known. The New Jersey Zinc Company has large works at Palmerton, the development of which town is due largely to the location of this company in the area. Large quantities of material used in these works must be shipped in from outside the area. The original introducton may well have occurred in this way.

Opportunity for observations have been of necessity limited and have been directed mostly to the extent of its invasion and occupancy of the local area rather than to its adaptation to its new or adopted environment. However in and about Lehigh Gap and upstream along the Lehigh River there are many natural, rather barren, largely eroded areas with sparse vegetation. Some of these areas have been affected in part by fumes discharged by operations of the zinc works. Others have been disturbed by road and railroad building and also there are about the town of Palmerton and the zinc works the usual habitats suitable for weed invasion to be found in any settled community. It is about such

areas that the species seems to occur in its greatest frequence and abundance even though it has been observed in and about yards of residences and in other situations.

Botanists active in field work are made constantly aware of the changes occurring in our flora, particularly perhaps in our more settled areas, by reason of private building as well as public works, resulting in the disturbance or even complete destruction of natural areas together with much if not all of the existing native flora. More interesting perhaps is the invasion of our more settled and often congested areas by foreign species, as well as by plants native to our own country, which has resulted in a very recognizably changing flora. It is not strange that there should be such changes in a living flora, but to some field workers it seems unfortunate that more observations of such changes are not published. In the present instance it is quite obvious that we have here an example of a native plant species that has apparently very definitely established itself in a region not closely adjacent to that of its natural range and, in at least some respects, different in its balanced plant association. It is yet to be discovered just how aggressive the plant may become. Certainly in the period over which it has been very generally observed it has noticeably increased in frequency and abundance. Where it may be going nobody knows but certainly it appears to be on its way.—HAROLD W. PRETZ, Allentown, Pa.

NOTES FROM RECENT BOTANICAL LITERATURE[1]

H. W. RICKETT

Ecology. Ecologists are still busy evaluating their fundamental concepts. R. H. Whittaker elaborates the "pattern hypothesis" of climax as contrasted with the older "monoclimax" and "polyclimax" theories (Ecol. Monogr. **23**: 41–78). J. S. Beard describes and analyzes the savanna vegetation of northern South America (Ecol. Monogr. **23**: 149–215). In his view this is not a climatic formation, like steppe; nor is fire the limiting factor, though the plants are fire-resistant; he attributes it to poor drainage of the soil and the lack of a true water-table. Asprey and Robbins describe the vegetation of Jamaica and classify its formations (Ecol. Monogr. **23**: 359–412); they found no evidence of a primitive rain-forest. Stephen G. Boyce studied salt-spray communities at Cape Fear and Cape Cod, analyzing the effect of the spray on dune vegetation (Ecol. Monogr. **24**: 29–67); the plants suffer from chloride injury, the ions entering through abrasions caused by the persistent winds; this leads to the formation of lateral shoots in a dense canopy. Controlled burning has been much in the ecological air. Stephen H. Sperr finds that the Itasca stands of pine result from burning in the past, and if they are not burned again will be replaced by another type of forest (Ecology **35**: 21–25). J. M. Potzger gives us a history of climate and vegetation in Quebec, based on the study of 19 bogs (Canad. Jour. Bot. **31**: 383–401); the Laurentian ice-cap was followed by a relatively warm period, this in turn by a "period of deterioration" leading to a still warmer period marked by hemlock and broad-leaved trees; more recently the climate has cooled again, with a peak of spruce and fir. A study was made by Brodie and Gregory on the dispersal of spores from cup-shaped bodies (Canad. Jour. Bot. **31**: 402–410. *pl. 1*). *Lycopodium* spores were placed in various types of vessels and on slides and subjected to winds varying in velocity from 0.6 to 7.1 m./sec. They were blown out more readily from funnels than from rectangular vessels or even from horizontal slides. A complex eddy system in the funnels, which accounts for the dispersal, was demonstrated with smoke.

Plant physiology. The vast field of plant physiology disappears into the distant horizons of biochemistry and bacteriology; it is more than ever difficult for a plain botanist (if there be such a creature) to know what is going on. Recent progress in the understanding of photosynthesis is reviewed by Brown and Frenkel (Ann. Rev. Pl. Physiol. **4**: 23–58), with special attention to the efficiency of the process, to the metabolism of phosphorus, and to the source of the oxygen. [Eugene Rabinowitch furnished a previous review in the same periodical (**3**: 229–264); he is the author of a monumental work on the subject, still in process of completion.] Among the other topics reviewed in

[1] See Bull. Torrey Club **81**: 251–253; 364–367.

this volume are nitrogen metabolism (J. G. Wood, 1–22), the growth of fruits (J. P. Nitsch, 199–236) and of roots (H. Burström, 237–252), growth substances (H. Veldstra, 151–198) and herbicides (A. S. Crafts, 253–282), mycorrhiza (E. Melin, 325–346), fluorescent substances (R. H. Goodwin, 282–304), the physical properties of protoplasm (H. I. Virgin, 363–382).

Many studies have recently been made on the trace elements. Symptoms of molybdenum deficiency in tobacco were reported by Robert A. Steinberg (Plant Physiol. **28**: 319–322); they included curling and mottling, bending and twisting of leaf-blades, and final withering of the leaves; such symptoms appeared first in the middle leaves, like those of zinc and copper deficiency, previously reported. On the other hand, molybdenum is accumulated by the cotton plant, according to Howard E. Joham (Plant Physiol. **28**: 275–280), reaching a concentration of 1583 ppm in the leaves; in this cotton resembles the legumes. Other species range from 5 to 220 ppm in molybdenum content. The high concentrations in cotton are associated with reduction in growth and with heavier infection by *Ascochyta gossypii*. Hannay and Street studied manganese and molybdenum requirements in cultures of excised roots of *Lycopersicon esculentum* and *L. pimpinellifolium* (New Phytol. **53**: 68–80). In White's medium manganese was found present in toxic concentrations, slowing meristematic activity; growth was enhanced by its "omission" (it was still present in minute amounts). In cultures with purified materials manganese and molybdenum deficiency resulted in death. Growth in such cultures was enhanced *in the absence of molybdenum* by adding manganese in concentrations which would normally be toxic; and vice versa.

According to Gauch and Dugger (Plant Physiol. **28**: 457–466), boron reacts with sugar in the plant, and the borated sugar moves through cell membranes more readily than does sugar alone; it is therefore important in translocation. Bertil Hylmö shows that the rate of $CaCl_2$ uptake is proportional to the rate of transpiration—contrary to most earlier reports,[2] which he says were based on insufficiently controlled experiments of too short duration (Physiol. Plant. **6**: 331–405). The Ca ion was taken up in three "phases": a rapid initial absorption by diffusion; accumulation in the vacuoles; and transport by the transpiration stream. The latter is thought to be a direct effect, called "mass transport." He also offers a hypothesis of root pressure. Bonner, Bandurski and Millerd show that the increased rate of water uptake by *Helianthus* tuber treated with IAA (first shown for potato in 1938) is related to respiration (Physiol. Plant. **6**: 511–521); they suggest that the increased respiration is due to the accumulation of water, and that the uptake of water even from hypertonic solutions indicates an "active" process of absorption, dependent on metabolic activity rather than simply on an osmotic gradient. This is denied by Hans Burström (Physiol. Plant. **6**: 685–691), who shows that the soluble carbohydrates of the tuber cause a rapid increase in osmotic value when the tuber is placed in water.

Radioactive isotopes have become a valuable new tool in the attack on old problems, including translocation. Fraser and Mawson injected Ru^{98} and Ca^{45} into trunks of yellow birch and white pine, and traced their movement with a newly developed scintillation counter (Canad. Jour. Bot. **31**: 324–333. *pl. 1*). The Ru moved upward in a spiral course in birch, at a rate which reached 1 ft./min. This rise ceased in October, but a downward flow in the phloem was observed later. Swanson and Whitney applied P^{32}, K^{42}, Ca^{45}, Cs^{137} to leaves and studied their movement through the petioles and stems (Am. Jour. Bot. **40**: 816–823). Low temperatures "inhibited" (they mean "reduced") the movement, and killing the petiole with steam stopped it altogether. Similarly the downward flow in the stem was slowed by low temperature, but not the upward movement. Different elements moved downward at different rates. N^{15} in the ammonium radical of ammonium nitrate was used by Schuler, Diller and Kersten to show that *Chlorella* "prefers" ammoniacal N

[2] Contrary also to what many of us have taught our students; but in conformity with many of the older textbooks, which by disregarding current evidence attained what is perhaps the truth!

to nitrate (Plant Physiol. **28**: 299–303). Joseph C. O'Kelley demonstrated by means of C^{14} that cotton fibers grow throughout their length, not only at base or apex.

P. F. Wareing shows (Physiol. Plant. **6**: 692–706) that bud-break of *Fagus sylvatica* is caused by short dark periods (i.e. in effect by "long days"). No chilling is necessary; plants grown in a warm greenhouse opened their buds normally in March. Bruce M. Pollock, on the basis of studies of respiration in buds of *Acer* (Physiol. Plant. **6**: 47–64), suggests that a growth-inhibitor is concerned in winter dormancy, perhaps a product of an aerobic respiration. Elliott and Leopold claim to have demonstrated an inhibitor of germination in the hull of the grain of *Avena* (Physiol. Plant. **6**: 65–77). It leaches out readily in water, and operates by inhibiting the activity of enzymes. Wangermann and Lacey have studied "ageing" in *Lemna*, measured by the ability of the plant to form new fronds (New Phytol. **52**: 298–311). Ageing is shown to depend on a growth substance; not auxin, since the process is not affected by factors which upset the effects of auxin.

D. J. Carr shows that detached leaves from which axillary meristem has been carefully removed cannot be "induced" photo-periodically (Physiol. Plant. **6**: 672–679; 680–684). Debudded plants do not hold any residual effect of photo-induction. He used *Xanthium* and *Chenopodium*. McIlrath and Ergle have demonstrated a persistence of the 2,4-D "stimulus" in cotton plants (Plant Physiol. **28**: 693–702). Malformed leaves continued to appear through several months, exceeding in number (they say) the primordia present at the time of treatment. This is contrary to results obtained by others with other species. A growth-regulator was extracted from treated plants 80 days after treatment; its identity was not established, but it caused the same sort of deformations as the original treatment.

An "eyeless" mutant of *Chlamydomonas* was studied by J. N. Hartshorne (New Phytol. **52**: 292–297). It is weakly sensitive to light, which shows that this response resides to some extent in the protoplast as a whole, even without the pigment of the "eye spot."

Plant pathology. Dimond and Waggoner have discussed the ambiguity of the word "toxin" (Phytopathology **43**: 229–235). Toxic compounds produced by plant pathogens have not been generally shown to cause the symptoms of the diseases. These authors propose the word "vivotoxin" for a substance produced by a pathogen in the host which "functions in the production of the disease," and furnish examples.

Armin C. Braun used naphthalene-acetic acid to induce crown-gall tumor-tissue to organize roots; but this was only successful when the tumor had its origin in a short exposure of tissue to bacteria (Phytopathology **43**: 204, 205). He showed also that the behavior of tumor-tissue, especially the formation of buds, depends partly on its position in the host; also on the strain of bacteria (Bot. Gaz. **114**: 363–371). Richard M. Klein attacks the problem of the chemical nature of the tissue-inducing principle. His evidence suggests that it is a polymer of desoxyribose nucleic acid (Am. Jour. Bot. **40**: 597–599).

Of three soil fumigants studied by R. H. Wensley (Canad. Jour. Bot. **31**: 277–308), methyl bromide proved the most effective, ethylene bromide the least. The latter is recommended for use against root-knot nematodes. Such fumigants alter the biological balance in the soil, usually in favor of the fungi which are otherwise suppressed by aspergilli and penicillia. Fusaria are more resistant to methyl bromide, according to C. D. McKeen (Canad. Jour. Bot. **32**: 101–115); he suspects that the demonstrably good effects of fumigation on the growth of vegetables may be partly due to nutritive factors and not entirely to the elimination of parasites. Another substance tested in soil is thiram (tetramethylthiuram disulphide); L. T. Richardson found that it caused a decrease in fungi and an increase in bacteria; it suppressed *Pythium ultimum* and thus protected seedlings against damping off (Canad. Jour. Bot. **32**: 335–346. *pl. 1, 2*). The newest thing in the control of insects is the "systemic" insecticide; i.e. a substance which (applied either to the plant or to the soil) becomes distributed through the plant and is poisonous to insects feeding on the plant. The most promising of these is "OMPA" (octamethyl pyrophosphoramide). Wedding and Metcalf have "labeled" this substance with radioactive phosphorus (P^{32}) and studied its translocation in beans (Bot. Gaz. **114**: 180–189). It is accumulated in the younger tissues.

Lachance and Perrault have discovered 30 species of soil organisms antagonistic to *Fusarium oxysporum* f. *lini*, which causes flax wilt (Canad. Jour. Bot. **31**: 515–521). In greenhouse tests wilting was delayed by the presence of these organisms; but they did not afford complete protection. Leander F. Johnson has used soil organisms, mostly actinomycetes, to control *Pythium* root rot of corn (Phytopathology **44**: 69–73). Mitchell, Zaumeyer and Preston have shown that streptomycin can be absorbed by and translocated in bean plants, moving upwards and outwards; control of halo blight was demonstrated (Phytopathology **44**: 25–30).

Many efforts to control plant diseases by breeding for resistance were reported in Phytopathology (**43**: 239–259, 297–303). In many crops (tobacco, celery, cucurbits, beets) resistance has unfortunately been associated with poor growth, and the aim of further research is to introduce better growth factors into the resistant strains. E. E. Clayton (239–244) describes how this is being done in tobacco by the use of other species. Munger and Newhall discuss resistance in celery and cucurbits (254–259). Stevenson and Akeley (245–253) describe the goal of potato-breeding as the combination in one variety of resistance to as many diseases as possible. Seedlings have been obtained resistant to as many as five major diseases. According to George H. Coons, the breeding program probably saved the beet industry (297–303). Sceffler and Walker (Phytopathology **44**: 94–101) describe a method of inoculating tomato cuttings, before rooting, with *Fusarium*. They used resistant and susceptible varieties, and the success of the operation, they say, disposes of theories of resistance based on properties of the roots; the fungus became distributed throughout the stem of all varieties. In resistant varieties the fungus disappeared gradually from the upper parts, which suggests that resistance may be due to metabolic products.

A. G. Plakidas grafted a variegated camellia to a nonvariegated plant; the latter formed variegated leaves and flowers (Phytopathology **44**: 14–18). This indicates that the variegation is due to an infectious agent, presumably a virus, rather than being genetic as had been assumed.

An extensive series of papers in the Canadian Journal of Botany deals with forest pathology. A recent article by Vidar J. Nordin (**32**: 221–258. *pl. 1–17*) is concerned with decay in sugar maples. Seventy-four per cent of the trees are reported as decayed to some extent; 109 species of basidiomycetes were found on living and dead trees in Ontario. Sproston and Scott (Phytopathology **44**: 12, 13) show that decay of tapped sugar maples is caused by *Valsa leucostomoides*, and suggest a method of control.

New methods of classification are still sought by mycologists. M. A. Ragab has used hyphal characters in classifying Hydnaceae (Mycologia **45**: 941–946). S. J. Hughes uses conidia and conidiophores in classifying hyphomycetes into "sections," which should rather be called "tribes," since each includes many genera (Canad. Jour. Bot. **31**: 577–659).

S. M. Pady, C. D. Kelly and L. Kapica have been conducting an extensive survey of the microbiology of the air over Canada and the Atlantic Ocean (Canad. Jour. Bot. **31**: 90–122, 309–323; **32**: 202–212). They have demonstrated a great seasonal variation in the number of fungous spores (bacteria are more constant). Almost all the spores are of soil-inhabiting fungi, presumably from agricultural areas to the south. Their presence may afford a clue to the movements of air masses over North America. Arctic air was shown to be sterile in winter and to contain up to 115/cu. ft. fungous spores in summer, mostly non-viable. The air over the North Atlantic is classified as "polar" or "tropical" with a corresponding variation in the density of the spore population.

H. C. McGinnis describes the chromosomes of *Puccinia*, which are extremely small (Canad. Jour. Bot. **32**: 213, 214. *pl. 1*). Polyploidy is suggested, with a basic number of 3. Mary Barbara Maxwell describes the conidia of Thelephoraceae as haploid and uninucleate even when formed on dicaryotic hyphae (Canad. Jour. Bot. **32**: 259–280. *pl. 1, 2*). All isolates of one species were completely interfertile, but two groups were found among the conidia of one dicaryotic mycelium. No nuclear fusion occurred in the formation of conidia. The conclusion is drawn that the nuclei of a dicaryotic mycelium are of two different mating-types.

Alpha-radiations from radium and polonium were used by Sigmund Berk to produce various mutants of *Aspergillus;* these were mostly unstable, but one stable yellow mutant was found (Mycologia **44**: 723–735). Roman and Sands describe diploidization of cells of *Saccharomyces* (Proc. Nat. Acad. **39**: 171–179). Two types were found, one homozygous, the other heterozygous by a "mutation" at the mating-type locus. The former can mate but not sporulate; the latter sporulates but does not mate. Triploid and tetraploid zygotes were obtained.

James MacKey used fast neutrons to induce mutations in diploid barley and hexaploid wheat (Hereditas **40**: 65–180), his aim being to compare the mutation process at different stages of "ploidy." A "buffering" effect was found in the hexaploids; the mutations were more often dominant, but "concentrated on more peripheral characters than in a diploid." "Polyploidy," he writes, "restricts the organism to a narrower morphological frame but permits a richer and more subtle differentiation within this frame"—especially ecologically. Hence the hexaploid group of wheats is very homogeneous, while the diploids are segregated in several genera. He also discusses at length the "speltoid problem."

Ownbey and McCollum describe reciprocal crosses among three species of *Tragopogon* which gave evidence of "cytoplasmic inheritance" (Am. Jour. Bot. **40**: 788–796); not "completely" but "reasonably well established" and of possible evolutionary significance. Experimental hybrids closely simulated "hybrids" found in nature.—The New York Botanical Garden.

Field Trip Reports

April 11. St. John's in the Wilderness Service. This is an annual hiker's service held on Palm Sunday at St. John's in the Wilderness, St. John's, N. Y. All of the hiking clubs in the Greater New York area were well represented and the total attendance was about 300. The Ladies' Guild of the parish served large quantities of coffee and cake and their contribution is noted herein as an appreciative gesture. Previous to the service, the Torrey group explored the shore of Lily Pond, Harriman Park, but botanically there was nothing to report. Attendance; Torrey 4, Rockland-Audubon 2. Leader, J. Harry Lehr.

April 24. Audubon House, Jeffersonville, Pa. This was a joint trip with the Botanical Society of Pennsylvania. The trip had two objectives: (1) to see the house and its surroundings and (2) to botanize in the woods of the sanctuary. Highlights inside, of course, were the famous paintings of Audubon. In woods and meadow there were conspicuous displays of *Mertensia virginica* (Virginia cowslip) and *Stellaria pubera* (Wood starwort). Attendance 21, at least 8 Torrey members. Leaders: J. d'Arcy Northwood, E. T. Wherry, and L. E. Hand.

May 2. Van Cortlandt Park, Bronx, New York. Trees, shrubs, wild flowers, and birds of the Park were studied. *Epimedium rubrum* (Berberidaceae), a hardy perennial of rock gardens, and sometimes where its appearance is unaccounted for, aroused interest. Have you noticed its biternate leaflets and the curiously complex structure of the brilliantly attractive flowers? Attendance 3. Leader, Jane Meyer.

May 5. Hoffman's Station, Hunterdon County, N. J. Four immature bald eagles passed overhead as our trip began and nothing seen later matched this sight. A station for nodding trillium (*T. cernuum*) was found. Blue lupines (*L. perennis*) and wild columbine (*Aquilegia canadensis*) were located on a railroad embankment, growing among coal, traprock and ashes like some rampant *Equisetum*. Attendance 33. Leader, David Fables.

May 8–9. Shehawken, Pa. Latitude 42 parallel, elevation 2,000 ft., temperature range 30 to 44 degrees Fahrenheit. The neglect of the Field Trip Committee to properly advertise this trip, or to mention any objective, may have been a factor in the small attendance. Only a very enthusiastic botanist would travel 300 miles for a few hours in the field.

Woods, fields, swamps, and bogs of this area were explored. Along the side of a rocky cascade *Polystichum Braunii* was observed, not yet fully expanded. This is one of the three areas in Pennsylvania where this fern of a more northerly distribution can be found.

Among other less common plants of this area seen on this trip were *Eriophorum callitrix*, in bog, *Claytonia caroliniana* in rocky woods, *Myrica gale* in swamp, *Lonicera canadensis* occasionally in light woods, *Andromeda glaucophylla* and *Kalmia polifolia* in bog, *Rhodora canadensis* in swamp (the only reported occurrence intermediate between the mountains of New York and the Pocono area, and *Polemonium reptans* in a meadow near a residence, possibly an introduction. The scarcity of *Trillium undulatum* in some areas was noticed, due probably to the unusual absence of the protective covering of snow in the past winter. Attendance 5. Leader, W. L. Dix.

May 14–16. Sussex County Nature Conference at High Point State Park. There were about 100 species of birds observed, including a hermit thrush evidently "on territory" near the Lodge at High Point. The Highlight of the botanical excursions, a visit to Mashipacong Bog, did not prove to be as productive as was hoped for, but dwarf mistletoe (*Arceuthobium pusillum*) was located on some black spruces (*Picea mariana*), while several plants of *Kalmia polifolia* were in bloom, as well as many three-leaved Solomon's seal (*Smilacena trifolia*). Attendance 45. Leaders, Louis Hand, Guy Nearing, and David Fables.

[For a more extensive discourse on the vegetation of this area see "The Past and Present Vegetation of High Point State Park, New Jersey" by William A. Niering in ECOLOGICAL MONOGRAPHS 23: 127–148. 1953. Ed.]

May 16. The New York Botanical Garden. This date found the Rock Garden in real beauty and the azaleas must have been at their height of bloom. The tour also included the Rose Garden and the Lorillard Snuff Mill. Attendance 15. Leader, Jane Meyer.

May 23. Inwood Park, New York. Being the season of migration, attention was largely focused upon a wave of warblers and eleven kinds were found in the Park. Botanically, this date was ideal for seeing *Paulownia* in full bloom. There are many trees of this species in the Park. Attendance 3. Leader, Jane Meyer.

May 23. Appalachian Trail, Kittatinny Ridge, N. J. This was a work trip covering our 4½ miles of the Trail between Millbrook road and Flatbrooksville road. Blazes were repainted; the Trail was cleared, including removal of some logs a foot or more—one was 13 inches in diameter. A list of the plants in flower was of gratifying length but of only the expected species. *Corydalis sempervirens* had begun its long flowering period and was the most conspicuous flower observed. Additional members and hikers should turn out for this maintenance work. Attendance 10. Leader, John A. Small.

May 29. Great Kills Marine Park, Staten Island. This was a bird trip, mostly, but the Daily List showed only 18 and no collecting of vouchers was attempted. Four clumps of *Hudsonia tomentosa* were found in bloom. This was perhaps a bit earlier than some years. It is to be hoped that this plant will be protected and will increase in the Park because it is becoming extremely rare on Staten Island. Another plant of the same habitat and flowering also at this time was *Linaria canadensis*. Attendance 14. Leader, Mathilde P. Weingartner.

June 6. Van Cortlandt Park, N. Y. In course of the usual study of trees, shrubs, and wild flowers, the group encountered a cat-tail marsh. Several long-billed marsh wrens were observed. A yellow-billed cuckoo was another outstanding sight. Attendance 8. Leader, Jane Meyer.

June 19. Marksboro, N. J. The trip covered limestone country. Among the plants observed were the uncommon *Carex flava*, the ever beautiful queen lady slipper (*Cypripedium reginae*), the yellow oak (*Quercus Muhlenbergii*), pale jewel-wood (*Impatiens pallida*) and *Viburnum Rafinesquianum*. Leader, David Fables.

June 20. Budd's Lake Bog, N. J. The character of the bog has undoubtedly changed greatly since the appearance of Britton's Catalogue (1889) and the present group found very few exposed areas of *Sphagnum*. The bog was largely shaded and overgrown by high-

bush blueberry (*Vaccinium corymbosum*), white azalea (*Rhododendron viscosum*), and speckled alder (*Alnus rugosa*). Still present, struggling against "overwhelming odds" in the battle for survival were: Pitcher plant (*Sarracenia purpurea*), round-leaved sundew (*Drosera rotundifolia*), wild calla (*Calla palustris*), wild iris (*Iris versicola*), three-fruited sedge (*Carex trisperma*), buckbean (*Menyanthes trifoliata*), bog rosemary (*Andromeda glaucophylla*), black spruce (*Picea mariana*), and Tamarack (*Larix laricina*). It appears as though the "life span" of the bog is nearing its end. Approach to the bog was via canoe and the white water crowfoot (*Ranunculus trichophyllus*) was found en route. Attendance 17. Leader, David Fables.

Book Reviews

The Dynamics of Virus and Rickettsial Infections. International Symposium. Edited by F. W. Hartman, F. L. Horsfall, Jr., and J. G. Kidd. 461 pp. The Blakiston Company, Inc. $7.50.

An International Symposium on the Dynamics of Viral and Rickettsial infections was held on October 21–23, 1953 at Detroit, Michigan, in order to provide an occasion for the exchange of ideas and information among workers in the bacterial, plant, and animal fields. The Symposium was sponsored by the Henry Ford Hospital and the proceedings were published in full by the Blakiston Company, Inc.

The Symposium volume containing the papers of 33 invited speakers was divided into five major categories: (1) Mechanisms of viral and rickettsial infections, (2) Ecology and pathogenesis, (3) Mechanisms of immunity, (4) Methods of virus and rickettsial diagnosis, and (5) Chemical approaches to prophylaxis and therapy.

One of the foremost problems in the animal, bacterial, and plant virus fields, the mechanism of virus reproduction, was given much attention. This problem was approached through studies on surface interactions, cell penetration, metabolic transformations, chemical composition of viruses, genetic inheritance of virus characters, and by-products of reproduction.

Instead of attempting to summarize all the findings reported and all the conclusions put forward, I shall limit this review to a more detailed discussion of the three papers which seem of special interest to plant workers. These were the following communications: "Cellular Metabolism and Virus Growth," presented by F. C. Bawden, Rothamsted Experimental Station; "Plant Viruses and Proteins," by Barry Commoner, Henry Shaw School of Botany, Washington University, St. Louis, Mo.; and "Maintenance of Yellows-Type Viruses in Plant and Insect Reservoirs," by L. O. Kunkel, The Rockefeller Institute for Medical Research, New York.

F. C. Bawden pointed out the advantages and disadvantages of using plants for virus work. All stages of plant virus infection seem to be affected to a considerable degree by the metabolism of the host cells. The ability to grow and to survive in widely differing environments makes higher plants excellent subjects for demonstrating how intimately all phases of virus diseases depend on changes in illumination, temperature, and nutrition. Infections in many plants proceed without killing the host and lack of antibodies provides an opportunity for the study of virus multiplication over long periods. Of prime significance among the disadvantages is the need for a wound in order to inoculate plant cells. Then too, there is no way of knowing the number of cells that are infected and whether an increase in the amount of extractable virus occurs because more virus has been produced in cells already infected or because more cells have become infected. The precision in quantitative work, as exemplified by the plaque technique in bacteriophage and Dulbecco's plaque technique for animal viruses, has not yet been attained by plant workers. Although non-infective particles have been found in several plant viruses, their origin and role is still uncertain.

Nutrients that increase plant growth increase both plant susceptibility to infection and virus multiplication. In nitrogen-deficient plants, tobacco mosaic virus largely replaces the normal leaf proteins and in systemically infected leaves, particularly if

they have abundant phosphorus, it may amount to more than two-thirds of the total protein. Bawden and Kassanis found that, when extra nitrogen is provided, the virus content of the leaves increases, but the normal proteins increase proportionately more, so that, although the virus concentration can be doubled, the ratio of virus to total protein may fall to less than 1 to 4. Although some workers have regarded the proteins that are replaced by the virus as virus precursors, there is no evidence to support the view that any proteins of the healthy cells are transformed directly into virus.

Susceptibility to infection can be inhibited by some chemical substances. Thiouracil and guanazolo were found to decrease tobacco mosaic virus multiplication and both substances have been found to be incorporated in the nucleic acid of tobacco mosaic virus. One explanation of the mechanism of thiouracil inhibition is that it interferes with multiplication by influencing the synthetic mechanisms of the host; other interpretations, however, are equally plausible. Further studies on the action of such substances promise to give information on the mechanism involved in virus multiplication and its relationship to host-cell metabolism; they may also disclose possibilities of chemotherapy for virus diseases. Bawden is not too optimistic about this, however, because he fears the viruses may have such limited independent activities that chemicals used to stop them would also seriously disturb the host. The paper is concluded with the following remark: "The view that viruses do not depend on the host simply for a supply of metabolites, but also for the mechanisms by which they are synthesized, fits present knowledge, but I hope it will prove unfounded. This is not because I have any philosophical prejudices in favour of viruses being organisms with independent activities, but because I think the prospects of successful chemotherapy would be so much better if they were."

Investigations of the biochemistry of tobacco mosaic virus reproduction are described by Barry Commoner. The reproduction of the virus is preceded by an increase in the insoluble nucleoprotein of the host tissue. This may be related to the formation of cell particulates which perhaps are the site of synthesis of virus protein. The appearance of three new low molecular weight proteins accompanies reproduction of tobacco mosaic virus. These proteins, not associated with nucleic acids, appear later than the virus. They are serologically related to the virus and can be polymerized. The three proteins as well as the virus appear to be formed from free ammonia of the host without the utilization of the pool of free amino acids.

Mixing of nucleic acid obtained from tobacco mosaic virus with low molecular weight protein (B8) yielded an artificial nucleoprotein which was not infectious.

L. O. Kunkel discussed in his paper an entirely different type of viruses, known to cause yellows-type diseases of plants. He calls attention to the fact that tobacco mosaic virus is very stable, readily transmitted mechanically and distributed throughout the world by tobacco users. It survives heating at 90° C for 10 min. and was the first plant virus found to be antigenic and to mutate, and also the first virus to be filtered and crystallized, photographed, and studied chemically. In contrast to it, the virus causing aster yellows disease, the best known of the yellows-type diseases, is one of the most unstable of all the known viruses, having a thermal inactivation point well below the thermal death point of some of its host plants. It is not transmitted by rubbing, nor retained in dry leaves. And still—it is very dynamic in its spread and it has one important advantage over tobacco mosaic virus which accounts for its admirable success in nature. While tobacco mosaic virus infects only plants, aster yellows virus infects, in addition, a certain leafhopper—an animal—which acts as an unusually efficient vector. The damage caused by an aster leafhopper in transmitting the virus depends on two major factors: the length of life of the insect and its individual efficiency as a transmitter. Some insects are good, others are poor transmitters. Perhaps the virus multiplies more rapidly or reaches a higher concentration in the good transmitters than in the poor ones. Some insects apparently are infected much more readily than others although all seem susceptible to infection. A transmission record of 228 leafhoppers, tested individually, showed that some insects became infective after a 2-hour infective feeding period, while others did not become infected during a 1-week infective feeding period. All insects which had access to diseased plants for 14 days and lived long enough

to be appropriately tested transmitted the virus. There were thus no aster leafhoppers that could be called immune from the aster yellows virus, but their individual susceptibility varied considerably. Perhaps all, or at least a considerable number of insects, remained infective as long as they lived.

The aster leafhopper is an efficient transmitter and a superb reservoir of the virus and therefore the virus spreads and flourishes in this country at least as well as tobacco mosaic virus. Kunkel found that a single infective individual feeding for one day will transmit to about 3 out of every 4 aster plants on which it feeds.

In the discussion of this paper an interesting comparison is made between the aster yellows virus and the curly top virus of sugar beets. It has been reported that curly top virus is retained for a long time by beet leafhoppers when they are allowed to become viruliferous through feeding on diseased beets for short periods. This correlation between the lengths of infective feeding periods, that is, presumably the amounts of virus taken up, and lengths of virus retention periods, has been presented by several workers as evidence that curly top virus does not multiply in its vector. Although in respect to the retention by vectors the curly top virus behaves differently from the aster yellows virus, in other important respects it behaves similarly. Even after 6 days of infective feeding periods some individuals of both species fail to become viruliferous, and only after long periods is every insect rendered infective. In the case of the aster leafhopper this is readily explained by assuming that some individuals are much less susceptible to infection. The multiplication of this virus has been demonstrated experimentally in the leafhopper vector. If the assumption were correct that in beet leafhoppers the curly top virus does not multiply, but that leafhoppers having a short infective feeding period take up a small "charge" of virus and those having a long infective feeding period take up a large "charge", then it would be difficult to understand why some individual leafhoppers require more than 6 days to become "charged". When a battery is being charged, shorter periods of charging will make it last shorter and longer charging will make it last longer, but all batteries would be expected to get some charge. This is obviously not the case with the "charging" of the beet leafhopper.

Other papers in the Symposium volume discussed the findings in animal and bacterial viruses. These reports will be of special interest to students of bacterial and animal diseases.

Stimulating speculations appear in the discussions following each chapter. These discussions were printed *verbatim* from wire recordings and the authors had no chance to see the proof. However, this procedure permitted faster printing of the volume. The paper is of good quality and the printing and general arrangements of the book are excellent.

The book has the flavor of those written by investigators and not mere reporters of the work of others. The authoritative status of the authors in the fields they write on makes the volume a required reference work for investigators who are engaged in the rapidly growing field of virus research.—KARL MARAMOROSCH, The Laboratories of the Rockefeller Institute for Medical Research, New York, New York.

Growth and Differentiation in Plants. Walter E. Loomis, Ed. Iowa State College Press. 1953.

This volume is presented as the third in the Monograph Series of the American Society of Plant Physiologists. The topics included are generally reviewed and evaluated through 1950, although some pertinent references were included up to 1953.

The first two chapters are intended to give the reader an introduction to various aspects of development. Thus, in chapter 2 on *Plant Morphogenesis*, the problems of development are briefly but clearly defined in terms of correlations, polarity, differentiation, regeneration, genetic factors, and morphogenetic factors, physical and chemical. While some of these problems are developed later, it is particularly unfortunate that no references are cited in such an important chapter. It is unfortunate, too, that the

outline and summary introduced in the first two chapters are not followed in the later chapters so that topical coherence seems lacking.

Four chapters (3, 4, 11, 16) are concerned with structural and correlative aspects of morphogenesis, and chapter 7 deals with genetic factors. Chapter 3 deals in considerable detail with the chemical and physical factors of growth, particularly in roots. Chapter 5 treats differentiation in shoot and root axes. Both chapters are well-done and include a summary and extensive literature review. Chapter 4 presents current thinking on the nature of the primary cell wall. Some of the pertinent current literature was not reviewed and the conclusions are necessarily still tentative. Chapter 11 is a well-documented discussion of growth correlations, such as the relation of growth to differentiation, the development of root to shoot, or vegetative vs. reproductive growth. These are interpreted as due to competition for materials, polarity, hormone action or, possibly, transport mechanisms. Finally, in chapter 16, an experimental approach to the problem of growth and differentiation in cells is outlined. This involves biochemical distinctions between differentiating cells, perhaps as quantitative expressions of genes. Chapter 7 is titled *Heterosis*. While the term is reviewed and developed as synonymous with hybrid vigor, the chapter is primarily a consideration of gene action as related to growth or yield.

Following these considerations of a system capable of growth and differentiation, several chapters treat more fully than those outlined above the morphogenetic factors which influence growth and differentiation. Included here are discussions of *dormancy*, *photoperiod*, *vernalization*, *bioelectric fields*, and *hormones*.

The brief treatment of dormancy in chapter 8 reviews primarily the work of Crocker, et al. While reviewing the methods for breaking dormancy, the author points out that little is known about dormancy from the point of view of growth inhibition or growth initiation.

The chapters on photoperiod (9 and 14) offer an unusually clear and complete treatment, with an extensive and up-to-date bibliography. There is some duplication here, but this does not detract from the excellence of the combined results. The authors conclude that the photoperiodic response may be interpreted in terms of relative rates of synthesis and destruction of critical factors or, perhaps, in terms of auxins and antiauxins.

The concepts and techniques of vernalization presented in chapter 10 are complete but not new. The writer simply reviews the basic concepts and gives the results of experiments in which vegetable crop plants were subjected to temperature treatments.

The possible role of continuous bioelectric potentials as correlative mechanisms is summarized in chapter 12. The basic theory here is that the continuous bioelectric potentials arise from cellular oxidation, and the pathway or flow of the current (electrons or ions) is correlated with structural organic polarity—morphological patterns or chemical and physiological gradients.

Chapters 13 and 14 deal with hormone action. In the former, the *Physiology of Hormone Action* is clearly elucidated. Certain aspects of auxin terminology, nature, origin, morphological effects and mechanism of action are discussed. The discussion and the literature citations cover the most recent work. Chapter 14 is titled the *Hormonal Control of Flower Initiation*. As mentioned previously, this chapter mainly synthesizes the existing literature on photoperiodism.

With a system capable of development and a suitable environment, there must still be present a suitable source of energy before growth and differentiation can take place. Chapter 15 deals with the *Structure and Synthesis of Protoplasm*. The author reviews the microstructure and histochemistry of the cell, and then gives a comprehensive treatment of protein synthesis. Finally, to complete the discussion of energy requirements, chapter 18 outlines the *Comparative Physiology of Heterotrophic Growth in Plants*. The author is concerned with carbon sources, intermediate metabolism, and growth factors as related to growth where carbon dioxide is not the carbon source. The discussion and literature citations are very inclusive.

In contrast to the foregoing treatments, chapter 17 is concerned with *Some Factors Associated With Diseased Growth in Plants.* Causal agents for diseased growth in plants are listed. In addition to these trigger agents, however, the authors consider the influence of mineral salts, sources of carbon and nitrogen, and various metabolites that stimulate or inhibit growth. Diseased growth is considered to develop from an imbalance of critical factors. Conversely, for normal growth, a number of factors operate in a suitable balance. The authors, in a very thorough fashion, show the value of the tissue culture technique for studying growth in any cell. A voluminous and critical review of the literature is included.

Finally, chapter 6 presents *Some Elementary Mathematics of Plant Growth.* Granted that growth should be represented by an adequate mathematical interpretation, a better purpose would have been served if the various methods of representing growth had been compared for their validity and usefulness.

A comprehensive author and subject index is included at the end of the book.

The topical organization of this book leaves much to be desired, so that more unifying comments than those contained in chapters 1, 2 and 11 seem necessary. At first reading, the reader is likely to feel that large segments of information pertinent to a well-rounded discussion of growth and differentiation are lacking. However, if the reader will disregard the chapter headings and read for actual content, while making some sort of rearrangement of the material such as that indulged in by the reviewer, the volume will then appear as a very creditable analysis and summary of many factors related to growth and differentiation.—J. E. GUNCKEL, Rutgers University, New Brunswick, N. J.

The Secret of the Green Thumb. By Dr. Henry T. Northen and Rebecca T. Northen. 430 pp., illustrated. The Ronald Press, New York. 1954. $5.

In 21 chapters Dr. and Mrs. Northen have given a complete picture on a condensed scale of the essential knowledge and understanding required to not only become a successful gardener, but also to appreciate the basic principles of plant growth, plant breeding, propagation, pest control, etc. and their applications. I believe that this book fills a great need in bringing to the reader scientific facts presented in a lucid, easily understood manner in conjunction with essential practical information. This volume satisfies the curiosity and thirst for knowledge of the intelligent gardener, and it is, therefore, a much needed addition to our vast collection of literature on gardening of a largely practical nature. It has a wide scope and the entire volume is extremely well illustrated and has an unusually complete index.

Their first chapter deals with the life story of plants. It explains the functions of the reproductive organs, pollination, the development of seeds and fruits. Chapter 2 discusses the wonderfully efficient mechanism of roots, stems and leaves and their separate and related functions, a truly enlightening story to the uninitiated. The next chapter is concerned with the need and effect of water and lack of it in relation to growth. It speaks of practical means to reduce loss of water in propagation, in the growing of plants and after transplanting. The latest methods of applying waxes and polyethylene are considered.

A 10 page chapter is devoted to the role of oxygen. The phenomenon of respiration is explained in detail and the role of oxygen for the use of bacteria and the decay of organic matter. It explains how in a well aerated soil, water is absorbed rapidly while in a poorly aerated clay soil the absorption is very slow. In chapter 5 the reader is enlightened on the function of photosynthesis in the manufacture of sugar for plant growth. Particularly the role of carbon dioxide is stressed and the importance of every green leaf for the health of your lawn, annuals, perennials, shrubs or trees. The next chapter is concerned with the effect of more or less light on plants. Sound information on the growth and propagation of plants in the basement by the use of fluorescent light is presented. Orchids, foliage plants, flowering plants, annuals, perennials, shrubs, trees and grass for shady places are enumerated. Another chapter considers the effect of

low, medium and high temperature on plants. The beneficial as well as harmful effects are treated. Suggestions for the prevention of winterkill are of practical value. There is a large chapter, 30 pages, on soils and nutrition. It contains a table exhibiting the symptoms of the effects of deficiencies of the major and minor elements. Soil acidity, soil texture and soilless culture or hydroponics are discussed in considerable detail. The subject of plant hormones in their connection with the beneficial stimulation in the rooting of cuttings and the harmful and death causing stimulation in the control of weeds is fully explained. This chapter also gives a list of plants which are more or less sensitive to the effect of the well known 2-4D hormone, used primarily as a weed killer.

Under the heading "Seasonal Phenomena" the reader is made aware of the transition from one season to another. The effect of regional difference in climatic conditions and their influence on flowering and fruiting is interestingly put forth. This chapter also includes an extensive enumeration by months of the flowering sequence of trees and shrubs starting in February with vernal witchhazel and ending in October with Japanese bush clover.

A 30 page chapter on "Planting and Propagation" discusses seed sowing with the best dates for annuals and vegetables and their subsequent treatment. Modern methods and ingredients are mentioned in considerable detail. The transplanting of trees and shrubs and possibility of spraying them with plastic latex to reduce transpiration when in full leaf is described. The propagation by divisions, bulbs, runners, roots, stem, leaf and root cuttings, layering, budding and grafting is given considerable space and is illuminated with excellent illustrations. Flowering and the effects of day length and temperature are interestingly explained while the chapter closes with the flowering period of our most beloved annuals and perennials. "Plant Breeding" and "Heredity" are given separate chapters. Hybridization, the selection of parents and the mechanics of the crossing of plants is fully explained. The illustrations pertaining to this work are very helpful. They show the crossing of gladiolus, African Violets and Iris.

The chapter on "Heredity" explains the function of the cells and the great importance of chromosomes and genes. It is altogether a very educational story for the more scientific minded amateur and told in easily understood language. Twenty pages are devoted to insects and other garden pests. All the common insects and their control with the latest insecticides are fully treated. Exceptionally fine pictures add greatly to the text. The chapter on Bacteria, Virus and Fungi is extremely fascinating and with its ample, detailed illustrations it makes a real contribution. A table with the host, name of the disease and fungus, symptoms and control for our most popular garden plants adds materially to its value.

One of the most interesting discussions is concerned with "Plants Without Seed." It brings home to the reader the fact that the plants we use in our gardens are not necessarily the most important plants in the world. One is made aware of the importance of bacteria, fungi, algae, mosses, liverworts, ferns and horsetails. It is pointed out that our marine animals depend directly or indirectly on the plant life in the sea. In one quart of ocean water are 1,000,000 or more algae. The giant Seaweed is the source of algin which is used in many products. A large chapter is devoted to seed plants. It starts with the evergreens and speaks briefly of their history and seed formation. There is much practical information on how to sow and plant them for effective garden use. Identification of the principal species is made clear through a comprehensive description. The part of this chapter on "Plants With Flowers" gives an historic as well as practical story on their development. The monocotyledonous plants (monocots) and dicotyledonous plants (dicots) are described and many examples are given. The principal families of each group are briefly treated. In the last three chapters the authors write very interestingly about "Evolution," "Plant Communities" and "Conservation." They are all important phases of plant life in relation to humanity. A geologic time chart is enlightening and shows the process of evolution in which the causal theories are briefly treated. In "Plant Communities" it is made clear that the location of plants in nature is not accidental as it might seem to the casual observer. It is pointed out that the

amount of precipitation determines the type of vegetation and that plant structures and habits are related to the water supply. The need for conservation of our land resources has been stressed in newspaper and magazine articles. The important resources are water, forests, grasslands and cultivated fields. This chapter emphasizes the need for a cooperative effort in the immediate future for the preservation and proper use of these resources in order to safeguard our economy and standard of living. This is brought into focus by the statement that 282 million acres of farm and grazing land have been ruined by erosion and 775 million acres are threatened with ruin. Good land not seriously threatened by erosion amounts to only 460 million acres.—HENRY M. BIEKART, Rutgers, the State University of New Jersey.

College Botany, revised edition. By Harry J. Fuller and Oswald Tippo. xiii + 993 pages, illustrated. Henry Holt & Co. 1954.

One wonders if the changes in the new Fuller & Tippo are sufficient to justify a new edition so soon after the first, especially in these days of expensive textbooks, and when so many students are desirous of purchasing a second-hand book.

However, relatively few as these changes are and as they needs must be, they are all in line with the most excellent research in plant studies, thus keeping this very excellent textbook right up-to-date. Two colored plates have been introduced: the frontispiece, a Crocus showing the major body parts and indicating their functions replaces the redwoods scene; the second plate, opposite page 464, has a longitudinal section of a flower showing the reproductive parts.

The major changes are to be found in chapters 8, 11, 15 and 16.

Chapter 8, page 153. The last sentence in the top paragraph where the authors speculated on the cause of the accelerative effects of organic fertilizers is omitted. Page 158. Latter half of paragraph omitted. The chapter ends with a new paragraph on "Soil Conditions" in which krilium is given special mention. The authors are careful to point out that these new compounds are not fertilizers. Their function is to improve the soil structure which in its turn will increase plant growth and yields.

Chapter 11, pages 210–212. There are many changes here. This chapter on the internal structure of stems, begins with a discussion of a meristem accompanied by a good, clear, labeled photomicrograph of a longitudinal section of the growing tip of Coleus, plus a page of line drawings interpreting a growing tip at various levels. On page 217 where the composition of xylem is mentioned vascular rays are omitted. I wonder why? Is it because the ray cells are either tracheids or parenchyma cells?

Chapter 15, page 321. This page, dealing with photosynthesis, is quite changed. The discussion is a clearer, simpler one with no speculation as to the intermediate products formed. The statement is made that "the first identifiable product of photosynthesis is phosphoglyceric acid." This is the compound which is eventually changed into a simple sugar, glucose, for example, which in its turn may "undergo a variety of chemical transformations." On page 324, the third paragraph is revised. "The basic feature in the process of photosynthesis" is the removal of hydrogen from water and its union with carbon dioxide. In some way, not understood at present, this process is carried on by chlorophyll and its associated pigments. As a result energy is stored. This energy will be released by a reversal of the above process, that is, when hydrogen breaks away from its union with carbon and reunites with oxygen. A new paragraph on the importance of leaves as photosynthetic organs is added on page 328.

Chapter 16, page 366. An interesting observation has been added in the last paragraph on the amount of heat generated during respiration,—"and in the masses of sprouting seeds, the temperatures are occasionally up to 80 degrees F. higher than those of the outside air." Pages 368–373 merit careful reading for there are changes here in the discussions of "Anaerobic respiration," "The mechanism of respiration," and "The use of radioactive elements and heavy isotopes in the study of metabolism."

There is a minor change to be found in Chapter 10, page 264: figs. 10–14, 10–15, bulbs, are replaced by fig. 10–14, a strawberry plant with runners (stolons).

The changes in the last two-thirds of the book are very few.

Chapters 23, page 610, Fig. 23–1, three photographs filling one page are reduced in size and a new one, fig. 23–2, added. On page 612, Fig. 23–3 has been replaced by a new one, fig. 23–4. These new figures are electron micrographs of bacteria.

It is interesting to note that in this revised edition the authors have kept the paging very similar to that of the first edition. This has been accomplished by the occasional dropping out of a figure, as on page 218, fig. 11–7, or a half blank page at the end of a chapter.—HETTIE M. CHUTE, New Jersey College for Women, Rutgers, The State University of New Jersey.

Pioneer Plant Geography. The Phytogeographical Researches of Sir Joseph Dalton Hooker. By W. B. Turrill. x plus 267 pages. (Vol. 4 of "Lotsya—A Biological Miscellany"). Twenty-one plates, one unnumbered figure. Martinus Nijhoff, the Hague. 1953. 19 guilders.

This volume, obviously a labor of love on Dr. Turrill's part, is more an addition to Hookeriana than to the field of plant geography. Sir Joseph Dalton Hooker (1817–1911) is perhaps best known as the co-author—with George Bentham—of the *Genera Plantarum* (1862–1883) and as an outstanding taxonomist and director of the Royal Gardens at Kew. He was an indefatigable botanical collector, and about thirty of his myriad publications reflect his wide floristic experience. While a devoted cataloguer of the flora of many regions, Hooker was not primarily interested in vegetation *per se*; nor was he interested in plant geography as we appreciate it today. The causes for the spatial distribution of plants were to him of lesser importance than their systematic relationships to each other and to the floras of other regions. Hooker was a keen observer and noted phenomena of vegetational dynamics not fully recognized at his time, but he generally sought taxonomic rather than physiologic relations when exploring a region hitherto unknown to him.

Dr. Turrill has divided Hooker's phytogeographical publications on the basis of the seven regions Hooker visited or studied from other botanist's collections. Eight chapters are thus devoted to Hooker's reports on the floras of Syria and Palestine, India, Africa, North America, the Galapagos and other islands, and the lands bordering the Arctic and Antarctic Oceans.

Each of these areas is discussed first by means of copious quotations from Hooker's writings. After cataloguing the species of a region, Hooker interpreted his data as to the families represented, the percentage of Monocotyledonae, percentage of Gramineae, and percentage of endemic species. By a comparison of these data, Hooker was able to draw conclusions regarding the origin and other relationships of the various floras he studied. In addition to these excerpts, Dr. Turrill has included a brief but interesting review of the regional phytogeographical literature published since Hooker's last visit to the given area. In many cases, Hooker's floristic interpretations have been further substantiated by more recent investigations; in others, his speculations have been superseded. Certainly, his monumental flora of India proper and his scheme of the Indian botanical provinces have only been slightly modified by subsequent workers.

In addition to the chapters dealing with regional floras, Dr. Turrill has included an interesting concluding chapter on the botanical problems faced by Hooker and his contemporaries, problems which in certain cases still confront botanists. The hypothesis of continental drift was unknown to both Hooker and Darwin, but the "extensionists" and "migrationists" were arguing about the origin of insular floras even then. While the *Genera Plantarum* is based on a natural system of classification, it is not a phylogenetic one, for both Bentham and Hooker eschewed Darwin's hypothesis at first. Gradually, Hooker embraced the evolutionary theory, and Dr. Turrill has emphasized the various stages in his conversion throughout the book, and especially so in the final chapter.

Pioneer Plant Geography would have benefited from a more judicious selection of plates or figures. Only one map is provided, (and even that does not provide sufficient de-

tail to orient the reader), despite the fact that the publisher was able to include 21 full-page glossy plates. These plates add little to the book. Many of them are Hooker's own sketches, and while charming, contribute neither to the botanical or aesthetic edification of the reader, their charm residing largely in the prevailing orthography (*viz.* "Boodhist" Monuments). Fifteen such sketches are provided. Two plates are devoted to photographs of Hooker's manuscripts, neither one demonstrating anything more than that his chirography was as decorative as it was illegible. American botanists will, however, be interested in an informal but excellent photograph (taken in Colorado in 1877) of Hooker and Asa Gray; the plant press held by the latter is the very same model in use today.

The lack of adequate maps is a serious defect of the book, the more so when one attempts to locate places no longer named as in Hooker's time. Only rarely does the author provide modern equivalents and then in obvious instances (*e. g.* Kilimanjaro for Kilima Njaro; Son for Soane River). Moreover, some of the areas visited by Hooker are of such small size that they are not found in the average atlas, and a few simple maps would have been extremely welcome.

Taxonomists will certainly find the book interesting, if not uniformly stimulating. Plant scientists interested in a more dynamic approach to plant geography than that outlined by Hooker's floristic researches will wonder at the choice of title. A pioneer is one followed by others who build on his preliminary work. Hooker's studies provide no such outstanding analogy in modern plant geography, if the latter can be said to date from 1898 with the publication of A. F. W. Schimper's *Pflanzengeographie*. Schimper refers to only two (Himalayan Journals and Flora Indica) of Hooker's phytogeographical publications, although all but two of these were published much before 1885. One cannot ascribe this omission of the bulk of Hooker's work by Schimper to the fact that Hooker published in English. Percy Groom and Isaac Bayley Balfour revised and edited Schimper's text in 1903 as well as translating it into English, but neither did they mention any of Hooker's phytogeographical papers other than the two above. Clearly, his work cannot be considered as pioneering in plant geography as such. Hooker's studies represent a great contribution to the science of floristics, which is of course basic to a consideration of plant geography, but it must not be confused with the latter discipline.—GILY E. BARD, Columbia University.

The Web of Life, A first book of ecology. By John H. Storer, with an introduction by Fairfield Osborn. 144 pages, plus 24 unnumbered pages of photographs and text. The Devin-Adair Co., New York. 1953. $3.00.

Here is an ecology, which, while dealing with plants and animals, looks on them not primarily for their interest *per se*, but for their relations to man. The interrelatedness of all life to itself and to the rest of its environment is emphasized. The author, a thorough conservationist, is rightly appalled by the way in which man upsets the balance and destroys the environment. He sets forth the "basic ingredient" of his story in his summation: "Scientists have proved that it is possible to use the life-supporting natural resources of the world without destroying them. These resources can be renewed and made more productive with use. This is a triumph of the human intellect. The great and deciding test, however, still remains—whether man can coordinate knowledge into understanding and build within his heart the incentives and the wisdom to use these new-found powers wisely, and with responsibility for the common good."

The sub-title of the book, "a first book of ecology," indicates the author's audience. Comprehensible to any reasonably intelligent person, regardless of background of knowledge, it may well have considerable appeal and carry its conservation message to a public that has not yet been reached. In both college and senior high school it could find usefulness in the type of course known by such names as Problems of American Democracy, American Civilization, etc.—conservation being one of the largest problems confronting that generation. The style is lively and the book makes entertaining reading. (Since the publishers bring in a comparison to Carson's *The Sea Around Us*, it seems not unfair to say that, as literature, it is not, in this reviewer's opinion, in any way comparable.)

The handsome black and white photographs, forming a separate section in the middle of the book, are excellently reproduced. With their brief captions they, studied by themselves, tell an exciting story and convey Mr. Storer's message vividly. It is a bit surprising and disappointing, in view of Fairfield Osborn's introductory reference to Storer's "brilliant work as a wildlife observer and photographer," to find that he is responsible for but one of the 48 photographs. Doubtless, however, there is none to excel the picture he does use—most of them credited to various federal agencies and the Audubon Society. It seems a bit surprising (and perhaps slightly damning to the book) that the publishers and jacket artists didn't discover the meaning intended by the author in the word *web*. He did *not* have in mind that the web is a snare in which life is entangled and from which it struggles to escape. (It must be admitted, however, that a piece of fabric would not make an arresting jacket design.)

This reviewer feels that the author occasionally overreaches himself and makes questionable statement. For example, in his discussion (pp. 80–81) of forests and grasslands, he implies that trees and grasses are composed of different materials and that our largest animals were found on grassland because the richer soil produced grasses which could support their larger bodies. Also, in drawing on A. B. Williams' classic work on the dynamics of a beech-maple community near Cleveland, he states that "the gray squirrels . . . left the forest in a body," whereas Williams says, "in September they moved out." (Ecol. Monog. 6: 370, 1936.) One is left with the uneasy feeling that he may have used other data similarly. The bibliography is brief, and there are no citations to allow the reader to pursue a specific matter of interest. Even Williams' work is not listed in the bibliography, though several chapters are based on it, and the reader has no help except the complete name in the text. References to other studies do not even include the names of the workers.

By and large, however, the book is to be recommended to its audience.—HELEN F. BUELL.

Wild Flowers of Western Pennsylvania and the Upper Ohio Basin. O. E. Jennings, illus. by Andrey Avinoff. 2 vols. University of Pittsburgh Press. Pittsburgh, Penna. $60.00. 1953.

In 1530 there appeared the first volume of an eventual 3-volume work entitled "Herbarum vivae Eicones," prepared by Otto Brunfels, containing descriptions and illustrations of plants found growing in the vicinity of Strasburg, Germany. This work, one of the earliest of the "Herbals," won for its author designation as one of the "German Fathers of Botany," and might be said to have marked the opening of the modern period in the history of botany.

Hundreds of works have appeared in the 4 centuries and more since Brunfels' day that might be classed as "Herbals." More often these are called today regional or local "floras," but the aims of the authors must have been very similar to those of the "German Fathers," i.e., to provide a means for recognition of the plants of a given area.

One of the most sumptuous of "Herbals" has now appeared in our own day and in our own land. In the new "Wild Flowers of Western Pennsylvania . . . ", a master botanist and a master painter have combined their talents and efforts to produce a botanical masterpiece that will likely take its place among the finest books of its kind ever produced. Its publication has been made possible through the generosity of the Buhl Foundation. The area included, "Western Pennsylvania and the Upper Ohio Basin" has no natural or sharp boundaries, and includes eastern Ohio, northern West Virginia, and western Maryland, in addition to western Pennsylvania.

The two volumes have been printed on a large-size page, 10¼″ × 14″, to permit life-size representation of the wild-flower paintings. Paper and binding are of high quality. Volume 1 contains 600 pages of information concerning about 2,000 species, including keys, descriptions, and distributional data, while volume 2 contains gravure reproductions of 200 water color plates, including 253 species of wild flowers, painted by Andrey Avinoff from living plants selected by Dr. Jennings.

In volume 1 about 75 introductory pages cover soils, climate, physiographic and topographic history, geology, plant geography, the historic development of botany in the region, a glossary, a gazeteer, a list of collectors and authorities, a systematic list of plant families, a key and a bibliography The more important species are illustrated with 146 range maps, showing distribution by counties in the various states. The data presented in volume 1 were assembled over a period of more than 50 years of intensive study by Dr. Jennings.

The illustrations in volume 2 are already recognized as works of art, in addition to their reputation for botanical accuracy. It is surprising that, despite our highly advanced methods of color reproduction, many botanical illustrations of our days are inferior to those published a century or more ago. This criticism does not hold for the reproductions of Dr. Avinoff's paintings, however, for they are truly superior. The illustrations appear facing pages of legends describing the paintings. The legends were written by Dr. Jennings and give informal accounts of the plants and the localities where they were collected. It seems quite likely that these plates will themselves some day be reproduced and framed as works of art, in the manner that Audubon's paintings are used today.

It is quite obvious that the usefulness of this work as a practical identification manual is restricted through the unwieldy size of the volumes, their high cost, and the limited edition, of only 3,000 copies. While it might momentarly be regretted that they will not be more readily available for this purpose, it is certain that this defect will be more than offset by the vaster influence the work will exert as a reference book and a work of art comparable to the finest that have ever been published in its field.

The accuracy of the descriptive material is beyond question. During the course of a long and busy career Dr. Jennings had studied intensively the flora of the region. He has personally explored virtually every county of the area covered. Thousands of herbarium specimens, at Carnegie Museum and elsewhere, were carefully studied. Hundreds of publications dealing with the subject were evaluated and their conclusions summarized. For many years Dr. Jennings labored at the task, at first with the idea of producing a field manual. Only later was the suggestion advanced that the paintings of Dr. Avinoff be published jointly with the descriptions. The combination has been a happy one.

No unfavorable criticism can be leveled at the manufacture of the book itself. The paper and binding are of a high quality, and the style of printing is pleasing to the eye. Typographical errors are virtually non-existent.

For a quarter of a century, this reviewer has been associated, if somewhat remotely, with Dr. Jennings in his study of the botany of the area. It is a distinct satisfaction to note especially how excellent has been the treatment of the subject, from the standpoint of the area that has been most familiar to the reviewer. It leads to the conclusion that other areas have been handled in as good, and probably even better, manner.

Pittsburgh has long been known to the world as a great industrial center. This work will serve to call attention to the fact that its contributions to the arts and sciences are not inconsiderable.—EARL L. CORE, West Virginia University.

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